MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XLII. MARCH 10, 1882. No. 5.

E. J. STONE, Esq., M.A., F.R.S., President, in the Chair.

Samuel Jefferson, Esq., 17 Virginia Road, Leeds; and James Leigh, Esq., Watford House, King's Norton, near Birmingham;

were balloted for, and duly elected Fellows of the Society.

Notes on M. Loewy's Remarks relative to the Wedge-Extinction Method of Stellar Photometry. By Prof. C. Pritchard, F.R.S.

In the *Monthly Notices* for January last, M. Loewy has done me the honour of criticising a method devised by me for the photometric measurement of the relative brightness of the stars, which I somewhat fully described in the *Monthly Notices* of November 1881. He states that he himself and his two associates MM. Paul and Prosper Henry have for several years been engaged in considering various photometric methods devised for the same purpose; and, among other methods, that which I have proposed, and, indeed, to a very considerable extent carried out with what seems to be success. M. Loewy states that the French astronomers abandoned this method. I would here remark that, in a question of this sort, it seems desirable to give numerical instances of a sufficient number of observations, in order that other astronomers may form an independent opinion, and clearly see for themselves the merits or demerits of the question at issue. This I have endeavoured to do in the paper of November last, giving many results as they were obtained direct from the heavens and the photometer. The results there given, though quite satisfactory, were first

attempts; and could be, and have been, improved by larger experience and additional precautions.

Besides this, the method adopted at Oxford is, I thought and still think, peculiar; and is most probably by no means that which, in its completeness, was tried and is said to have failed at the Paris Observatory. I shall soon explain more at large what I mean as I proceed.

M. Loewy objects to the plan of extinction by a wedge, because (unless I mistranslate or misunderstand his remarks) he found that the reducing of the light by means of the wedge to the extent of seven or eight magnitudes, introduced serious inconveniences.

Now, in my plan of using the wedge, I have uniformly avoided any such process as comparing the light of two stars differing by seven or eight magnitudes, *by means of the wedge alone*. Further, M. Loewy adds that they found it necessary to confine themselves to differences of magnitude not exceeding three magnitudes in the use of the wedge alone. To this I agree *in practice*; but, with the wedge in my possession, I could extend the use of it much further; certainly to six magnitudes without the "introduction of sensible errors."

But what is done, in effect, is this. A star of a magnitude intermediate between those which it is proposed to examine, is selected. In *Lyra*, for instance, κ *Lyræ* was selected about magnitude $4\frac{1}{2}$, and other stars in its neighbourhood, from the first to the eighth magnitude, were examined and compared with it, so that there could be no great or violent differences in the lights compared.

Again, I do not trust to the wedge-extinction process alone; but in such a case as comparing κ *Lyræ* with α *Lyræ*, the brighter star (α) would be observed in a telescope with an aperture of (say) two inches, whereas the fainter star (κ) would be observed with an aperture of 4 inches; thus removing at once an amount of light from the brighter star, equivalent to a magnitude and a half, leaving the wedge to act upon a difference of light amounting to about $2\frac{1}{2}$ magnitudes only, which, in my present wedge, implies the use of less than an inch and a half: and even this amount of wedge interval might be still further reduced, by diminishing the aperture of the telescope to one inch, as is often done in practice at this Observatory. In fact, the telescope used has an aperture of four inches, reducible to three inches, two inches, and one inch, at pleasure. But my experience is not in favour of too violent a reduction of aperture.

Hence it will be observed that my method of photometry is a mixed method of aperture and wedge, each continually testing and verifying the other—a great gain, as I conceive. Thus, I submit, I have successfully met M. Loewy's natural objection to the use of a wedge beyond reasonable limits, however perfect it may be. Probably, however, I did not sufficiently explain this point of practice in my November paper.

The next objection to the process of wedge-extinction urged by M. Loewy is apparently more formidable. It applies to the material itself of the glass wedge. He states that the Paris astronomers, after a trial of some fifty specimens of neutral-tinted glass, invariably found that they were differently absorbent for different colours. If that were universally the case, and if this difference of absorbing power were decidedly marked, then, I presume, the method of wedge-extinction must be abandoned. But my experience is contrary to that of the French astronomers.

I have submitted the wedge—or, rather, the two wedges—to a scrupulous and exhaustive trial. Their effect on a Sun spectrum I have found to be uniformly absorptive for all the colours, extending from the violet to beyond *B* in the red. A little beyond *B*, noticeable absorption commences. But this is just the part of the spectrum where the light of ordinary stars becomes very feeble, and, consequently, the wedge is trustworthy; excepting, it may be, in the case of a star of a decidedly red colour. But this is, unfortunately, one of the cases where neither the eye nor any photometer that I know can be fully trusted in the comparison of different intensities of light. In a delicate question of this sort, I thought it best to consult one of the highest authorities in this country, Dr. Huggins. He at once referred me to a passage, written by himself, in the *Philosophical Transactions* for 1866, in which he says: "An examination of the neutral-tint glass, with a prism, showed that the absorptive power of the glass, for all refrangibilities in the brighter portion of the spectrum, was very nearly uniform." That eminent physicist was good enough to examine, also, a few other specimens of neutral-tinted glass in his possession, with a substantially similar result; and he adds, in a private communication to me, "In the case of the stars visible to the naked eye, among which there are no very red stars, the wedge would give results quite comparable probably with those of any other method, because any small errors arising from the want of absorptive uniformity would doubtless be much smaller than the unavoidable errors of estimation coming in from other causes."

This cautious expression of opinion, after due and skilful examination on Dr. Huggins' part, entirely coincides with my own experience, after the use of the wedge some thousand times. Thus, I think, M. Loewy's second objection is satisfactorily removed.

M. Loewy then proceeds to explain another method which he had devised, but which he, not unnaturally, doubts if it be new. It is to virtually reduce the aperture of the telescope by means of a moveable pierced diaphragm, placed inside the telescope, and near to the eyepiece. He is quite right in the suspicion that the method is not new. Our well-remembered colleague Mr. Dawes constructed and used a similar apparatus, described in the *Monthly Notices*, vol. xxv. p. 229. But I am

not aware that Mr. Dawes obtained any considerable results, either by that means, or by another means in which, like myself, he employed variable apertures and wedge combined. The cause, or causes, of failure—for a practical failure it seems to have been—are not difficult now to see. Most probably M. Loewy will avoid them.

I have tried the method of small apertures, but I abandoned it in despair—possibly I was impatient. With a wedge, used unskilfully enough, some five years ago, I was equally impatient and equally unsuccessful. But a patient re-consideration of the whole case has now landed me in what I believe to be a valuable and trustworthy photometric method.

I now proceed to what I regard as an actual test of the reliability and value of the method employed in this Observatory from which may be formed a safe and practical conclusion in regard to the points raised by M. Loewy.

Professor Pickering has devised a photometer of a peculiar construction, depending on double refraction. It resolves itself at last into the comparison or equalisation of lights of two stars placed in a very skilful way in juxtaposition. I need not say that this is the very antithesis of the method I employ. Results obtained by means of the two instruments and the two methods, if they be employed on the same star, must, on comparison, necessarily reveal facts. Now, it so happens, that Professor Pickering has recorded his results of the measurement of the difference of brightness of twenty-six stars of the *Pleiades*. Out of these twenty-six, fifteen have already been observed in Oxford,* as well as some twenty others of this group, not observed at Harvard College. The Oxford observations are the results of three nights' measurement of each star—five readings of the instrument being taken on each night. Finally, the means are taken, and the average deviations of the fifteen separate measures from their general mean, are recorded in the subjoined tables. An inspection of these results will enable astronomers to judge of what has been so far achieved, and what sort of promise the method or methods hold out, for the photometric estimation of relative star-magnitudes.

* Since the writing of this paper, the photometric measurement of forty-three stars in the *Pleiades* has been completed. Of these, forty have been also carefully measured as to their relative coordinates with the Duplex Micrometer, in order to compare them with Bessel's Heliometer measures. The results, it is expected, will be communicated to the Society in May next.

TABLE I.

Comparison of the Magnitudes of Fifteen Stars in the Pleiades that have been Photometrically obtained by Observations made at Harvard College and at Oxford.

Bessel's Designation.	Observed Differences of Magnitude from Merope. 1	2	3	Mean difference of Mag.	Average Deviation.	Resulting Oxford Mag. Merope = 4·22.	Resulting Harvard Magnitude.
17 *b* Electra	0·31	0·62	0·41	0·45	0·12	3·77	3·82
16 *g* Celæno	1·01	1·15	1·28	1·15	0·09	5·37	5·23
19 *e* Taygeta	0·35	0·44	0·32	0·37	0·05	4·59	4·44
18 *m*	1·65	1·68	1·53	1·62	0·06	5·84	5·63
21 *k* Asterope	1·52	1·68	1·54	1·58	0·07	5·80	5·71
22 *l*	1·98	2·22	2·15	2·12	0·09	6·34	6·28
20 *c* Maia	0·19	0·50	0·34	0·34	0·10	3·88	3·98
10	2·87	2·78	3·16	2·94	0·15	7·16	6·96
19	2·68	2·64	2·29	2·54	0·16	6·76	6·69
22	2·65	2·59	2·28	2·51	0·15	6·73	6·74
25 η Alcyone	1·29	1·34	1·35	1·33	0·02	2·89	3·00
24	2·43	2·12	2·18	2·24	0·12	6·46	6·46
12	2·54	2·27	2·48	2·43	0·11	6·65	6·58
26 *s*	2·34	2·20	2·10	2·21	0·08	6·43	6·36
29	2·54	2·39	2·49	2·47	0·06	6·69	6·56

TABLE II.

Individual and Concluded Measures of the Magnitude of Eighteen Stars in the Pleiades made at Oxford. (*Not observed by Prof. Pickering.*)

Bessel's Designation.	Diff. from Merope.	Observed Differences of Magnitude from Merope. 1	2	3	Mean difference of Mag.	Average Deviation.	Resulting Oxford Mag. if Merope = 4·22.
1	3·0	2·95	2·99	3·10	3·01	0·06	7·23
4	3·0	3·38	3·36	3·28	3·34	0·04	7·56
6	4·0	5·14	5·00	4·93	5·02	0·08	9·24
7	3·0	3·17	3·36	3·20	3·24	0·08	7·46
8	3·5	3·16	3·11	3·30	3·19	0·07	7·41
9	3·5	3·68	3·67	3·59	3·65	0·04	7·87
13	3·5	3·94	3·70	4·07	3·90	0·14	8·12
24 *p*	2·5	1·66	1·55	1·65	1·62	0·05	5·84
15	3·5	4·30	4·15	4·41	4·29	0·09	8·51
17	3·0	2·36	2·47	2·47	2·43	0·05	6·65
18	3·0	3·78	3·68	3·96	3·81	0·10	8·03
21	3·5	3·74	4·02	3·93	3·90	0·10	8·12
23	3·5	3·19	3·24	3·22	3·22	0·02	7·44
30	3·5	3·55	3·76	3·46	3·59	0·11	7·81
31	3·0	2·41	2·49	2·64	2·51	0·08	6·73
33	3·5	3·06	2·98	2·89	2·98	0·06	7·20
35	4·0	5·29	5·39	5·38	5·35	0·04	9·57
36	4·0	4·50	4·60	4·65	4·58	0·06	8·80

The only remark necessary to make with regard to the above Tables is that the observations themselves are all differential. The magnitude assigned to *Merope*, which is the Oxford star of comparison, was 4·22, that being the value assigned to it by Professor Pickering. Argelander's value is 4·5. Had I assumed the magnitude of *Merope* as 4·16, instead of 4·22 with Professor Pickering (a course perfectly allowable), then the general agreement of the Oxford with the Harvard magnitudes would have been still more remarkably close.

Professor Pickering, in some valuable remarks which he has contributed to the *Astronomical Register* of February 1882, after kindly expressing the interest which he takes in the Oxford Observations, observes:—"In all forms of the method I have found the observed limit of visibility inconveniently variable, not only on different nights, and for different observers on the same night, but even in successive measures by the same observer at short intervals. The separate determinations included in a single series are sufficiently accordant; but, on returning subsequently to the same object, a new result is often obtained, so that strictly differential measures cannot be made satisfactorily." In reply to this, I have looked carefully through a large mass of observations, made by the same observer on different nights and on the same night, and the result is, that the average deviations of all the several readings from the mean of the whole is sensibly the same as that which is recorded in the *Astronomical Register* as the result of the Harvard Observations. With regard to the fifteen stars in question observed by the two methods, the Harvard mean deviation is 0·13 magnitude; the Oxford, 0·10 magnitude. On this head, too, I have with great interest consulted Professor Pickering's valuable photometric observations, in vol. xi. of the Harvard College Observations, where deviations of a very similar character and amount are exhibited. In fact there seems to me to be a limit to the accuracy to which stellar magnitudes are at present determinable, notwithstanding the skill of the observer or the ingenuity displayed in the construction of his instrument. Nevertheless, that limit is vastly beyond the amount of accuracy which has hitherto been secured by unaided comparisons with the eye.

As to the employment and results of different observers on the same or different nights, I have seen no differences such as in any degree to shake my confidence. I have, in fact, obtained on this head additional confirmation of what I have stated in the addendum to my paper in the *Monthly Notices*, November 1881, p. 11. Nevertheless, it is to be distinctly understood that, for the method of wedge-extinction, it is essential for accuracy that the meteorological circumstances under which any two stars are compared must be sensibly the same. Drifting clouds form the chief difficulty with which the observer has to contend, and I think it probable that it is this circumstance which explains Professor Pickering's remarks on occasional discordant results.

But meteorological effects on astronomical observations are not confined to photometry.

I have arranged a third Table, from which astronomers may form an opinion of the *advance* which is now being made in the accuracy and consistency of the estimates of the brightness of stars.

TABLE III.

Comparison of the Photometric Measures of the Magnitude of Fifteen Stars in the Pleiades made at Harvard and Oxford with the estimation of the Magnitude of the same stars made by Bessel, Argelander, and Wolf.

Name of Star.	Difference of Magnitude from Merope, Bessel.	Argelander.	Wolf.	Pickering.	Pritchard.
17 *b* Electra	−0·5	+0·2	−1·0	−0·40	−0·45
16 *g* Celæno	+0·5	+2·0	+0·5	+1·01	+1·15
19 *e* Taygeta	0·0	+0·5	0·0	+0·22	+0·37
18 *m*	+2·0	+1·8	+0·75	+1·41	+1·62
21 *κ* Asterope	+2·5	+2·5	+1·0	+1·49	+1·58
22 *l*	+2·5	+2·5	+1·5	+2·06	+2·12
20 *c* Maia	0·0	+0·3	−1·0	−0·24	−0·34
10	+3·0	+3·5	+2·25	+2·74	+2·94
19	+3·0	+3·0	+2·75	+2·47	+2·54
22	+3·0	+3·0	+2·75	+2·52	+2·51
25 *η* Alcyone	−1·5	−1·3	−2 5	−1·22	−1·33
24	+3·0	+2·5	+2 0	+2·24	+2·24
12	+2·5	+3·0	+2·0	+2·36	+2·43
26 *s*	+2·5	+2·5	+2·0	+2·14	+2·21
29	+3·0	+3·3	+2·0	+2·34	+2·47

The minus sign implies that the particular star was brighter than *Merope*.

It is almost unnecessary to point out how closely the photometric measures made at Harvard and Oxford agree, in comparison with the estimations made by the careful and eminent astronomers who have given their attention to the same subject. Nevertheless, it is somewhat curious to remark that the *means* of the estimations made by Bessel, Argelander, and Wolf (widely as they individually differ from each other), agree in the main with the more accurate photometric measures.

Oxford University Observatory:
1882, *March* 9.

Spectroscopic Results for the Motions of Stars in the Line of Sight, obtained at the Royal Observatory, Greenwich, in the year 1881. No. V.

(*Communicated by the Astronomer Royal.*)

The results here given are in continuation of those printed in the *Monthly Notices*, vol. xxxvi. p. 318, vol. xxxvii. p. 22, vol. xxxviii. p. 493, and vol. xli. p. 109. The observations were made with the "half-prism" spectroscope, one "half-prism" with a dispersion of about 18°½ from A to H being used, except in a few cases of bright stars, mentioned in the remarks, where a train of two "half-prisms," with a dispersion of 83° from A to H, was used. An eyepiece with a magnifying power of 14 was employed throughout. Since the beginning of 1881 a convex cylindrical lens, with its axis parallel to the length of the spectrum, has been placed in the view-telescope within the focus, instead of in front of the slit as before. Thus the angle of divergence of the rays which fall on the object-glass of the collimator is not affected, as was formerly the case. A concave or Barlow lens of 2 inches focus has been placed in the collimator between the slit and the object-glass, so that the whole aperture of the object-glass and of the prisms may be used, the ratio of aperture to focal length being greater for the collimator of the spectroscope than for the refractor. In most of the observations a diaphragm coated with Balmain's luminous paint has been used in the micrometer-adapter to give a phosphorescent illumination of the field.

Up to the present time the motions of 99 stars have been spectroscopically determined, though the results in many cases are still very uncertain.

The observations of the moon and of the sky spectrum have been made as usual as a check on the general accuracy of the results.

Motions of Stars in the Line of Sight in Miles per Second, observed with the Half-prism Spectroscope.

(+ denotes Recession; − Approach.)

The initials W. C. and M. are those of Mr. Christie and Mr. Maunder respectively.

The weights are on a scale of ½ to 5 for each observation.

Stars marked with an asterisk have not been previously observed.

Date.	Obs.	Wt.	Line.	Earth's Motion in m. per sec.	Concluded Motion of Star. Meas.	Concluded Motion of Star. Estimd.	Remarks.
					α Andromedæ.		
1881.							
Sept. 30	M	3	F	− 1·3	−23·0	−23·7	Star line dark, not very broad,
	M	3	F	− 1·3	−28·6	−32·0	though somewhat ill defined at the edges. Spectrum steady.
	M	3	F	− 1·3	−15·4	−15·4	

Date. 1881.	Obs.	Wt.	Line.	Earth's Motion in m. per sec.	Concluded Motion of Star. Meas.	Estimd.	Remarks.
Dec. 3	M	2	F	+14·7	−37·5	−37·2	Star-line dark, but broad, ill defined and nebulous.
	M	2	F	+14·7	−57·2	−50·6	
	M	2	F	+14·7	−46·1	−41·7	
7	M	3	F	+15·3	−43·7	−42·6	Definition fair. Direct comparison showed only a small displacement.
	M	3	F	+15·3	−50·4	−48·0	
				β Cassiopeiæ.			
Dec. 7	M	½	F	+ 8·1	−42·9	−35·4	Star-line not very broad; but very difficult to bisect.
	M	½	F	+ 8·1	−38·9	−35·4	
	M	½	F	+ 8·1	−25·7	−26·3	
				γ Pegasi.			
Dec. 3	M	2	F	+16·7	−23·8	−23·1	Star-line faint, broad and very diffused at the edges.
	M	2	F	+16·7	−48·1	−43·7	
	M	2	F	+16·7	−43·5	−39·2	
				*δ Andromedæ.**			
Nov. 19	M	3	b_1	+10·0	−72·0	−68·5	Spectrum faint and tremulous, but definition good at times.
	M	3	b_1	+10·0	−52·1	−49·0	
22	M	1	b_1	+11·2	− 2·2	− 1·0	Definition variable.
	M	3	b_1	+11·2	−30·3	−31·6	
	M	2	b_1	+11·2	−46·3	−62·3	
				*β Ceti.**			
Nov. 19	M	4	b_1	+14·7	−45·5	−53·7	Spectrum tremulous, but star-lines seen well at times.
	M	4	b_1	+14·7	−47·4	−53·7	
28	M	1	b_1	+16·1	−28·6	−28·0	Definition poor and star-lines faint.
	M	1	b_1	+16·1	−14·2	− 7·8	
	M	1	b_1	+16·1	−32·9	−32·8	
				γ Cassiopeiæ.			
Dec. 7	M	2	F	+ 6·9	−20·5	−20·5	The star-line, being bright instead of dark, was difficult to bisect.
	M	2	F	+ 6·9	−18·5	−17·8	
	M	2	F	+ 6·9	−28·2	−25·1	
				β Andromedæ.			
Oct. 18	M	3	b_1	− 0·8	+44·8	+44·9	Spectrum bright. Star-lines dark and fairly well defined.
	M	3	b_1	− 0·8	+42·9	+44·9	
Nov. 19	M	2	b_1	+ 8·2	−30·0	−32·6	Image tremulous, definition variable.
	M	2	b_1	+ 8·2	−56·1	−56·9	
22	M	½	b_1	+ 9·0	−57·7	−60·1	Definition poor.

Date.	Obs.	Wt.	Line.	Earth's Motion in m. per sec.	Concluded Motion of Star. Meas.	Estimd.	Remarks.
1881.							
Nov. 22	M	½	b_1	+ 9·0	− 5·5	+ 1·2	
	M	½	b_1	+ 9·0	+ 4·6	+11·4	
	M	½	b_1	+ 9·0	−56·6	−60·1	
					*δ Cassiopeiæ.**		
Dec. 7	M	2	F	+ 6·5	+16·9	+20·8	Star-line very broad. Spectrum faint.
	M	2	F	+ 6·5	+ 4·0	+ 4·4	
					*α Trianguli**.		
Nov. 19	M	3	b_1	+ 6·9	+54·7	+58·1	Spectrum faint, but steady.
	M	3	b_1	+ 6·9	+56·6	+58·1	
					α Arietis.		
Nov. 19	M	5	b_1	+ 6·9	−15·5	−16·6	Definition very good.
	M	5	b_1	+ 6·9	− 7·7	− 6·9	
	M	5	b_1	+ 6·9	− 6·5	− 6·9	
					α Ceti.		
Nov. 28	M	2	b_4	+ 7·6	−11·5	− 7·6	Definition poor.
	M	2	b_1	+ 7·6	−12·3	− 7·6	
	M	2	b_1	+ 7·6	−22·4	−24·3	
					*ρ Persei.**		
Nov. 22	M	½	b_4	+ 2·3	−37·8	−55·5	The star-line, b_4, was not distinctly isolated.
	M	½	b_4	+ 2·3	−53·8	−66·2	
	M	½	b_4	+ 2·3	−22·2	−23·6	
					ζ Persei.		
Oct. 18	M	1	b_1	−10·6	−14·3	−11·4	Star-lines faint. Definition poor.
	M	1	b_1	−10·6	−15·5	−11·4	
					*ε Tauri.**		
Nov. 22	M	2	b_1	− 1·9	+22·5	+27·5	Definition fair.
	M	2	b_1	− 1·9	+18·3	+27·5	
					Aldebaran.		
Mar. 28	M	2	b_1	+15·8	+78·6	+102·7	Star-lines dark, but difficult to isolate. Spectrum very tremulous. Definition poor.
	M	2	b_1	+15·8	+71·9	+102·7	
31	M	4	b_1	+15·3	+94·7	+ 62·3	Star-lines dark. Spectrum bright, but tremulous.
	M	4	b_1	+15·3	+78·7	+ 62·3	
	M	4	b_1	+15·3	+85·3	+ 62·3	
April 7	M	2	b_1	+13·9	+26·0	+ 24·6	Star-lines ill defined. Spectrum very faint and tremulous. Two-prism train.
	M	2	b_1	+13·9	+24·4	+ 24·0	

Date. 1881.	Obs.	Wt.	Line.	Earth's Motion in m. per sec.	Concluded Motion of Star. Meas.	Estimd.	Remarks.
Oct. 18	M	3	b_1	+12·4	+14·0	+12·4	Star-lines dark and distinct.
	M	3	b_1	+12·4	+27·1	+21·2	Spectrum very bright.
	M	3	b_1	+12·4	+37·7	+34·4	
Nov. 22	M	3	b_1	− 2·3	+40·5	+53·4	Definition poor.
	M	3	b_1	− 2·3	+31·5	+36·3	
	M	3	b_1	− 2·3	+ 4·6	+ 2·3	
28	M	3	b_1	− 0·4	+26·1	+21·3	Definition poor.
	M	3	b_1	− 0·4	+ 9·7	+ 8·7	
				Capella.			
Mar. 31	M	3	b_1	+15·8	+21·2	+23·0	Spectrum tremulous, but very bright. Definition fair.
	M	3	b_1	+15·8	+16·5	+23·0	
April 6	W.C.	2	b_1	+15·0		+51·0	Definition variable.
	W.C.	2	b_1	+15·0		+58·3	
7	M	5	b_1	+14·9	+37·1	+36·4	Spectrum bright. Definition fair. Two-prism train.
	M	5	b_1	+14·9	+37·3	+36·4	
	M	5	b_1	+14·9	+27·1	+27·9	
	M	5	b_4	+14·9	+28·2	+31·7	
				Rigel.			
Feb. 28	M	½	F	+16·0	+12·4	+19·9	Definition very bad.
	M	½	F	+16·0	+15·1	+19·9	
Mar. 14	M	2	F	+15·7	+31·5	+21·8	Spectrum tremulous. Definition poor.
	M	2	F	+15·7	+32·4	+21·8	
Dec. 7	M	5	F	+ 0·3	+15·1	+13·3	Spectrum bright, but tremulous.
	M	5	F	+ 0·3	+ 8·3	+10·6	
	M	5	F	+ 0·3	+14·2	+13·3	
				γ Orionis.			
Dec. 3	M	1	F	− 2·2	+30·0	+24·7	Definition poor.
	M	1	F	− 2·2	− 9·2	− 6·8	
	M	1	F	− 2·2	+ 1·6	+ 2·2	
				β Tauri.			
April 9	M	4	F	+15·9	+ 5·1	+17·4	Spectrum steady. Definition good.
	M	4	F	+15·9	+26·6	+44·0	
	M	4	F	+15·9	+13·7	+34·1	
Dec. 3	M	1	F	− 2·9	−19·9	−19·6	Star-line dark, and, though broad, fairly well defined.
	M	1	F	− 2·9	−14·7	−12·1	
	M	1	F	− 2·9	−12·2	− 8·4	

Date.	Obs.	Wt.	Line.	Earth's Motion in m. per sec.	Concluded Motion of Star. Meas.	Estimd.	Remarks.
				α Orionis.			
1881. Mar. 31	M	1	b_4	+17·1	+13·3	+22·5	Spectrum tremulous, but very bright. Definition of star lines fair.
	M	1	b_4	+17·1	+23·8	+22·5	
	M	1	b_1	+17·1	− 1·9	+ 2·3	
	M	3	b_1	+17·1	+35·9	+29·5	
April 7	M	3	b_1	+16·4	− 0·4	+ 5·0	Spectrum faint, but fairly steady. Definition fair. Two-prism train.
	M	3	b_1	+16·4	+ 6·1	+ 9·3	
	M	3	b_4	+16·4	+30·1	+24·4	
	M	3	b_4	+16·4	+ 6·5	+10·8	
Nov. 28	M	2	b_1	− 6·3	+26·6	+26·9	Definition poor.
	M	2	b_1	− 6·3	+53·5	+56·3	
				β Aurigæ.			
April 9	M	3	F	+15·8	+ 2·1	+ 9·2	Definition good, but star-line not quite so well seen as in β Tauri.
	M	3	F	+15·8	−13·7	−15·8	
				γ Geminorum.			
Feb. 28	M	½	F	+16·5	+11·0	+19·4	Definition bad. Measures uncertain.
	M	½	F	+16·5	− 7·6	− 4·5	
Mar. 14	M	1	F	+18·0	+ 8·5	+14·8	
	M	½	F	+18·0	+29·8	+25·8	
				Sirius.			
Feb. 16	M	½	F	+10·4	+ 9·6	+11·8	Spectrum very tremulous, and definition very bad.
	M	½	F	+10·4	+ 3·5	+11·8	
28	M	1	F	+12·2	+ 3·5	+11·8	Definition bad.
	M	1	F	+12·2	+14·6	+23·7	
Dec. 7	M		F	− 6·4	−23·5	−20·9	Spectrum very bright. Star-lines well seen. Direct comparison distinctly confirmed these measures.
	M		F	− 6·4	−19·8	−20·9	
				Castor.			
April 16	M	½	F	+17·7	−49·1	−51·1	Star-line very broad and diffused at the edges.
	M	½	F	+17·7	+22·1	+24·1	
				Procyon.			
Feb. 16	M	1	F	+10·2	+39·5	+43·1	Star-line faint. Spectrum faint, and definition bad.
	M	1	F	+10·2	+18·8	+23·1	
28	M	3	F	+13·0	+ 3·1	+ 2·0	Definition fair.
	M	3	F	+13·0	+ 1·8	+ 2·0	

Date. 1881.	Obs.	Wt.	Line.	Earth's Motion in m. per sec.	Concluded Motion of Star. Meas.	Estimd.	Remarks.
Mar. 14	M	2	F	+15·6	+13·1	+17·2	
	M	1	F	+15·6	+31·0	+28·2	
April 9	M	4	F	+17·6	+45·9	+57·4	Definition good.
	M	4	F	+17·6	+29·6	+49·0	
	M	3	F	+17·6	+17·1	+ 6·8	Spectrum faint. Two-prism train.
	M	2	F	+17·6	+12·1	+ 0·7	
				Pollux.			
Mar. 25	M	2	b_1	+17·5	−71·7	−82·4	Spectrum very bright and fairly steady. Star-lines faint and ill defined.
	M	2	b_1	+17·5	−17·9	−17·5	
	M	1	b_1	+17·5	−77·5	−82·4	
	M	1	b_1	+17·5	−15·9	−17·5	
28	M	3	b_1	+17·7	− 0·2	+11·9	Spectrum steady. Definition good.
	M	3	b_1	+17·7	+17·8	+21·8	
April 7	M	1	b_1	+18·1	−34·5	−39·5	Spectrum faint and tremulous. Star-lines faint. Definition poor. Two-prism train.
	M	1	b_4	+18·1	− 2·9	+ 2·3	
	M	1	b_1	+18·1	−17·7	−18·1	
	M	2	b_1	+18·1	−10·0	− 9·5	
	M	2	b_1	+18·1	−12·2	−13·8	
				α Hydræ.			
Mar. 31	M	1	b_1	+12·2	− 9·1	− 4·4	Spectrum tremulous and faint. Star-lines faint.
	M	1	b_1	+12·2	−16·1	−20·0	
				ε Leonis.			
Mar. 25	M	2	b_1	+13·2	+18·4	+19·3	Star-lines dark. Definition fair.
	M	2	b_1	+13·2	− 3·9	− 0·2	
				Regulus.			
May 11	M	½	F	+17·9	−23·5	−22·9	Definition fair.
	M	3	F	+17·9	+ 1·8	+ 1·8	
	M	3	F	+17·9	+ 3·1	+ 6·8	
				γ_1 Leonis.			
Mar. 25	M	1	b_1	+11·1	+31·4	+40·8	Star-lines exceedingly difficult to see.
	M	1	b_1	+11·1	+11·9	+14·9	
				δ Leonis.			
May 6	M	½	F	+16·0	+15·4	+11·4	Star-line faint and diffused.
	M	½	F	+16·0	+ 2·5	+ 2·3	
11	M	3	F	+16·6	+20·1	+20·4	Definition fair.
	M	3	F	+16·6	+16·1	+16·3	

Date.	Obs.	Wt.	Line.	Earth's Motion in m. per sec.	Concluded Motion of Star. Meas.	Concluded Motion of Star. Estimd.	Remarks.
				χ Ursæ Majoris.			
1881.							
May 20	M	½	F	+13·4	+21·1	+18·8	Spectrum faint. Star-line diffused and faint.
	M	½	F	+13·4	−20·5	−19·9	
				β Leonis.			
May 4	M	2	F	+13·1	+10·9	+12·4	Star-line very diffused.
	M	2	F	+13·1	−34·4	−32·2	
	M	2	F	+13·1	− 4·5	− 5·5	
11	M	½	F	+15·5	−28·1	−27·8	Definition very poor.
	M	½	F	+15·5	−39·8	−40·2	
				*β Virginis.**			
Mar. 25	M	½	b_1	+ 3·3	−49·7	−68·2	Spectrum faint.
	M	½	b_1	+ 3·3	−35·6	−46·6	
				δ Ursæ Majoris.			
May 20	M	1	F	+11·1	−14·8	−17·6	Star-line diffused.
	M	1	F	+11·1	−20·4	−17·6	
				γ Virginis.			
May 4	M	2	F	+10·6	+23·9	+27·6	Star-line diffused.
13	M	½	F	+12·7	+23·7	+17·1	Star-line dark. Spectrum faint, and definition bad.
	M	½	F	+12·7	− 1·6	− 1·5	
				α Canum Venaticorum.			
May 11	M	2	F	+11·7	−31·1	−28·2	Definition fair.
	M	2	F	+11·7	−41·9	−41·3	
				ε Virginis.			
Mar. 31	M	½	b_1	+10·1	−17·1	−17·9	Star-lines very faint.
	M	½	b_1	+10·1	+ 3·9	+ 9·3	
				Spica.			
May 13	M	3	F	+ 9·3	−21·6	−20·5	Star-line very faint.
	M	3	F	+ 9·3	−24·4	−24·2	
	M	2	F	+ 9·3	−35·5	−31·6	
	M	2	F	+ 9·3	−13·9	−13·8	
				ζ Ursæ Majoris.			
May 20	M	1	F	+ 9·6	+24·6	+29·1	Star-line very diffused and difficult to bisect.
	M	1	F	+ 9·6	+12·9	+22·6	
				η Ursæ Majoris.			
May 20	M	1	F	+ 9·4	+15·9	+16·4	Star-line very diffused and difficult to bisect. Images steady.
	M	1	F	+ 9·4	+27·3	+29·3	

Date.	Obs.	Wt.	Line.	Earth's Motion in m. per sec.	Concluded Motion of Star. Meas.	Concluded Motion of Star. Estimd.	Remarks.
				Arcturus.			
1881. June 22	M	3	b_1	+14·3	−25·3	−25·1	Definition variable, generally poor, but star-lines seen well at times. Two-prism train.
	M	3	b_1	+14·3	−38·6	−36·0	
				ϵ_2 Boötis.			
June 22	M	1	b_1	+12·2	+ 2·6	+ 0·9	Definition variable.
	M	1	b_1	+12·2	+18·6	+14·0	
				*β Boötis.**			
June 22	M	1	b_1	+ 9·7	−29·6	−35·9	Definition variable.
	M	1	b_1	+ 9·7	−54·5	−49·0	
				β Libræ.			
May 6	M	1	F	− 0·4	−32·0	−30·0	Star-line dark, but diffused, and somewhat difficult to bisect.
	M	1	F	− 0·4	−37·8	−30·0	
				α Coronæ.			
May 13	M	½	F	+ 2·8	+12·3	+12·1	Spectrum faint. Definition bad.
	M	½	F	+ 2·8	+16·9	+12·1	
				γ Herculis.			
May 6	M	½	F	− 2·6	−27·3	−24·8	Observation interrupted by cloud.
				α Herculis.			
June 22	M	½	b_4	+ 4·2	+32·0	+28·0	Definition very poor.
	M	½	b_4	+ 4·2	+ 4·8	+ 8·7	
				α Ophiuchi.			
Sept. 30	M	1	F	+14·2	−54·3	−39·2	Spectrum bright and steady. Star-line a broad faint nebulous haze.
	M	1	F	+14·2	−37·3	−30·9	
				γ Draconis.			
June 22	M	½	b_4	+ 0·4	+18·7	+21·4	Definition bad.
	M	½	b_4	+ 0·4	+ 9·3	+16·0	
				α Lyræ.			
Sept. 14	M	1	F	+ 8·0	−39·4	−31·2	Spectrum tremulous. Definition very bad.
	M	1	F	+ 8·0	−26·5	−19·6	
30	M	2	F	+ 8·6	−31·7	−31·1	Spectrum bright and fairly steady. Star-line ill defined.
	M	2	F	+ 8·6	−18·5	−21·1	
				γ Lyræ.			
Sept. 30	M	½	F	+10·3	−49·2	−47·7	Spectrum faint. Star-line very ill defined.
	M	½	F	+10·3	−38·7	−27·0	

Date.	Obs.	Wt.	Line.	Earth's Motion in m. per sec.	Concluded Motion of Star. Meas.	Concluded Motion of Star. Estimd.	Remarks.
				ζ Aquilæ.			
1881.							
Sept. 19	M	2	F	+13·7	−31·0	−25·9	Images steady. Star-line broad, diffused, and faint.
	M	2	F	+13·7	−30·4	−25·9	
	M	2	F	+13·7	−10·3	− 8·8	
				δ Aquilæ.			
Sept. 19	M	½	F	+15·0	+10·0	+ 4·6	Spectrum very faint. Measures worthless.
	M	½	F	+15·0	−85·3	−76·2	
				β Cygni.			
Oct. 25	M	2	b_1	+12·2	− 7·5	− 3·7	Spectrum faint. Star-lines exceedingly so.
	M	2	b_1	+12·2	−39·5	−40·5	
	M	2	b_1	+12·2	+23·7	+30·3	
	M	2	b_1	+12·2	−14·9	−12·2	
				δ Cygni.			
Sept. 30	M	1	F	+ 6·3	− 0·7	+ 0·8	Spectrum faint, but steady. Star-line dark, but ill defined at edges.
	M	1	F	+ 6·3	+17·4	+10·4	
				α Aquilæ.			
Sept. 30	M	1	F	+14·8	−22·8	−21·9	Spectrum tremulous. Star line very ill defined.
	M	1	F	+14·8	−13·6	−14·8	
	M	1	F	+14·8	−37·9	−39·8	
				α Cygni.			
Sept. 14	M	2	F	+ 2·9	+28·2	+20·3	Definition poor, evening misty.
	M	1	F	+ 2·9	−36·5	−26·1	
Oct. 18	M	1	b_1	+ 7·3	−33·8	−36·7	Definition poor, passing cloud.
	M	1	b_1	+ 7·3	−69·3	−66·1	
				ζ Cygni.			
Oct. 25	M	3	b_1	+11·8	+22·5	+30·7	Spectrum faint, but star-line fairly well seen.
Nov. 28	M	½	b_1	+13·6	−61·9	−63·6	Spectrum and star-lines very faint. Definition very bad.
	M	½	b_1	+13·6	+24·6	+28·1	
	M	½	b_1	+13·6	−11·7	−13 6	
	M	½	b_1	+13·6	−40·5	−41·4	
				α Cephei.			
Sept. 7	M	1	F	− 2·8	−59·8	−47·3	Star-line faint, broad, and diffused.
	M	2	F	− 2·8	−24·7	−39·0	

Date.	Obs.	Wt.	Line.	Earth's Motion in m. per sec.	Concluded Motion of Star. Meas.	Concluded Motion of Star. Estimd.	Remarks.
				*ζ Pegasi.**			
1881. Sept. 19	M	1	F	+ 3·8	+ 6·7	+ 8·4	Star-line fairly sharp, but faint.
	M	1	F	+ 3·8	+28·6	+25·6	
	M	2	F	+ 3·8	−14·0	−16·0	
				η Pegasi.			
Nov. 22	M	½	b_1	+14·1	−65·9	−65·2	Star-lines very faint, and definition very bad.
	M	½	b_1	+14·1	− 0·5	− 3·9	
	M	½	b_1	+14·1	− 9·4	− 3·9	
	M	½	b_1	+14·1	−22·3	−24·3	
28	M	½	b_1	+14·8	+13·3	+13·0	Star-lines very faint. Definition very bad.
	M	½	b_1	+14·8	−14·8	−14·8	
				Fomalhaut.			
Sept. 19	M	½	F	+ 7·2	−57·2	−56·1	Very unsatisfactory.
				β Pegasi.			
Nov. 19	M	1	b_1	+14·0	− 0·8	− 4·3	Star-line faint and difficult to bisect.
	M	1	b_1	+14·0	− 8·2	− 4·3	
	M	1	b_1	+14·0	−13·2	−14·0	
22	M	½	b_1	+14·4	−69·4	−75·7	
	M	½	b_1	+14·4	− 3·5	+ 0·2	
	M	½	b_1	+14·4	+44·5	+36·7	
	M	½	b_4	+14·4	+12·1	+21·1	
	M	½	b_4	+14·4	+ 0·8	+12·2	
				α Pegasi.			
Sept. 30	M	3	F	+ 4·8	−30·1	−29·8	Spectrum steady, definition fair.
	M	3	F	+ 4·8	−44·0	−34·8	
Dec. 3	M	1	F	+17·6	−12·3	−13·1	Star-line dark but broad and diffused.
	M	3	F	+17·6	−21·3	−22·1	
7	M	4	F	+17·7	−45·8	−45·0	Star-line broad and ill defined at edges.
	M	4	F	+17·7	−37·4	−31·3	

Date.	Observer.	No. of Obs.	Line.	Motion Measured.	Remarks.
		Moon.			
1881, March 14	M	7	F	−0·6	
April 6	W.C.	3	b_1	−3·5	
7	M	3	b_1	−0·5	Two prism-train.
9	M	2	F	−0·5	Two prism-train.
9	M	4	F	+0·2	
May 6	M	3	F	−2·4	
11	M	5	F	+0·8	
13	M	2	F	+0·3	
Nov. 28	M	5	b_1	−0·7	
Dec. 3	M	5	F	−2·5	
7	M	5	F	−1·2	
		Sky Spectrum.			
1881, Feb. 28	M	5	F	+11·2	
March 26	M	6	b_1	+ 0·3	
29	M	6	b_1	+ 0·3	
April 1	M	5	b_1	− 4·6	
17	M	5	F	− 1·6	
May 5	M	5	F	+ 0·4	
June 23	M	3	b_1	− 1·1	
23	M	3	b_1	− 1·4	Two prism-train.
Sept. 20	M	5	F	+ 1·7	
Oct. 1	M	5	F	− 0·9	
19	M	5	b_1	+ 1·8	
Nov. 21	M	5	b_1	− 0·4	
23	M	5	b_1	0·0	

Observations of Occultations of Stars by the Moon, and of Phenomena of Jupiter's Satellites, made at the Royal Observatory, Greenwich, in the year 1881.

(*Communicated by the Astronomer Royal.*)

Occultations of Stars by the Moon.

Day of Observation.	Phenomenon.	Telescope.	Power.	Moon's Limb.	Mean Solar Time of Observation. h m s	Observer.
1881, Jan. 5 (*a*)	Disapp. 19 Piscium	Altaz.	100	Dark	7 52 12·5	A. D.
12	Disapp. Piazzi V. 192	S. E. Eq.	320	„	7 16 50·4	M.
March 8	Disapp. Piazzi V. 338	E. Eq.	70	„	11 4 32·0	T.
16 (*b*)	Disapp. *q* Virginis	S. E. Eq.	130	Bright	12 1 0·9	M.
(*c*)	Reapp. *q* Virginis	„	130	Dark	12 57 0·1	„
May 4	Disapp. 5 Cancri	Altaz.	100	„	9 26 33·2	A. D.
Sept. 3	Disapp. 33 Sagittarii	E. Eq.	140	„	8 18 27·0	„
Oct. 5	Disapp. κ Piscium	Altaz.	100	„	12 9 5·6	L.
	Disapp. κ Piscium	E. Eq.	140	„	12 9 7·0	J.
	Disapp. 9 Piscium	Altaz.	100	„	12 13 47·9	L.
	Disapp. 9 Piscium	E. Eq.	140	„	12 13 46·7	J.
Oct. 9	Reapp. 54 Arietis	Altaz.	100	„	12 30 26·6	A. D.
Nov. 9 (*d*)	Reapp. 16 Geminorum	„	100	„	13 10 20·7	C.

(*a*) Instantaneous.
(*b*) The Moon's limb was smooth and regular at the point of disappearance. No projection. Disappearance not absolutely instantaneous.
(*c*) Very well seen; reappearance not absolutely instantaneous. (*d*) Much cloud about; observation doubtful.

Day of Observation.	Phenomenon.	Telescope.	Power.	Moon's Limb.	Mean Solar Time of Observation. h m	Observer.
1881, Nov. 12 (*e*)	Disapp. α Cancri	Altaz.	100	Bright	13 30 32·2	J. P.
	Reapp. α Cancri	,,	100	Dark	14 44 33·1	,,
29 (*f*)	Disapp. 16 Piscium	E. Eq.	310	,,	5 15 59·0	A. D.
	Disapp. 16 Piscium	Altaz.	100	,,	5 16 2·0	J. P.
(*g*)	Disapp. 19 Piscium	E. Eq.	140	,,	11 27 21·7	A. D.
Dec. 30 (*h*)	Disapp. ρ^2 Arietis	Altaz.	100	,,	5 31 6·3	T.
	Disapp. ρ^3 Arietis	E. Eq.	140	,,	5 31 6·1	A. P.

(*e*) Clouds passing. (*f*) The star became very faint before the disappearance.
(*g*) Instantaneous. (*h*) Image of star seemed disturbed on approaching the Moon's limb, but disappearance was instantaneous.

Phenomena of Jupiter's Satellites.

Day of Observation.	Satellite.	Phenomenon.	Telescope.	Power.	Mean Solar Time of Observation. h m s	Mean Solar Time of *N.A.* h m s	Observer.
1881, Jan 31	II.	Ec. R. First seen	E. Eq.	140	7 3 29	7 4 11	A. D.
Feb. 15	III.	Ec. D. Last seen	,,	,,	8 18 59	8 19 41	W. C.
		,,	Altaz.	100	8 19 13		J. P.
Sept. 19 (*a*)	II.	Oc. R. Last contact	E. Eq.	140	10 44 27	10 38 0	L.
Oct. 6	III.	Tr. I. First contact	,,	,,	10 59 27	11 1 0	T.
		Bisection	,,	,,	11 3 11		
	I.	Ec. D. Last seen	,,	,,	11 29 11	11 28 40	,,
14 (*b*)	I.	Tr. I. First contact	,,	,,	11 22 45		,,
		Bisection	,,	,,	11 25 45	11 26 0	H. P.
		Last contact	,,	,,	11 29 44		,,

Day of Observation.	Satellite.	Phenomenon.	Telescope.	Power.	Mean Solar Time of Observation. h m s	Mean Solar Time of *N.A.* h m s	Observer.
1881, Oct. 14	I.	Tr. E. Last contact	E. Eq.	140	13 38 53	13 37 0	H. P.
29	I.	Ec. D. Last seen	,,	,,	11 40 35	11 40 41	J. P.
31	I.	Oc. R. First seen	,,	310	8 37 6	8 39 0	C.
		Last contact	,,	,,	8 38 53		
(*c*)	III.	Ec. D. Last seen	,,	,,	9 3 39	9 0 48	C.
(*d*)	III.	,,	S. E. Eq.	320	9 3 40		M.
Nov. 22	II.	Ec. R. First seen	E. Eq.	140	7 33 26	7 33 41	J.
	I.	Tr. I. First contact	,,	,,	8 54 8	8 55 0	,,
		Bisection	,,	,,	8 56 18		
		Last contact	,,	,,	8 58 22		
23 (*e*)	I.	Oc. D. First contact	Altaz.	100	6 3 30	6 5 0	C.
		Last contact	,,	,,	6 6 20		
	I.	Ec. R. First seen	,,	,,	8 30 54	8 30 56	,,
28	I.	Oc. D. First contact	E. Eq.	310	13 22 31	13 23 0	,,
		Bisection	,,	,,	13 24 10		
		Last contact	,,	,,	13 25 20		

(*a*) Observed through thin cloud; observation rough.

(*b*) Limb of *Jupiter* diffused, but occasionally very well defined.

(*c*) Observation very unsatisfactory. Clouds continually passing across the planet.

(*d*) This phenomenon was observed through a narrow slit—*Jupiter* being well outside the slit—in order to see if any faint light from the satellite could be discerned after its entry into the shadow.

(*e*) Limb of *Jupiter* very tremulous; observation difficult.

Day of Observation.	Satellite.	Phenomenon.	Telescope.	Power.	Mean Solar Time of Observation. h m s	Mean Solar Time of *N.A.* h m s	Observer.
1881, Nov. 29	II.	Oc. D. First contact	E. Eq.	140	6 37 22	6 45 0	A. D.
		Bisection	,,	,,	6 43 21		
		Last contact	,,	,,	6 47 35		
	II.	Ec. R. First seen	,,	,,	10 8 27	10 9 1	,,
	I.	Tr. I. First contact	,,	,,	10 36 48	10 39 0	,,
		Bisection	,,	,,	10 40 42		
		Last contact	,,	,,	10 43 12		
Dec. 8 (*f*)	II.	Tr. E. Bisection	,,	,,	5 58 42	6 0 0	T.
		Last contact	,,	,,	6 0 32		
13 (*g*)	III.	Oc. R. Last contact	,,	100	7 43 5	7 42 0	H. C.
21	I.	Oc. D. First contact	,,	140	13 3 36	13 8 0	A. D.
		Bisection	,,	,,	13 6 35		
		Last contact	,,	,,	13 9 20		
30 (*h*)	I.	Oc. D. Bisection	,,	,,	9 21 47	9 24 0	A. P.
		Last contact	,,	,,	9 24 42		

(*f*) Sky hazy. (*g*) Very faint; sky foggy. (*h*) Limb of *Jupiter* diffused.

The clear aperture of the object-glass of the S.E. Equatoreal is $12\frac{3}{4}$ inches, of the E. Equatoreal 6·7 inches, and of the Altazimuth $3\frac{3}{4}$ inches.

The initials W. C., C., A. D., M., T., L., H. P., J. P., J., A. P., and H. C., are those of Mr. Christie, Mr. Criswick, Mr. Downing, Mr. Maunder, Mr. Thackeray, Mr. Lewis, Mr. H. Pead, Mr. Power, Mr. James, Mr. A. Pead, and Mr. Cox.

Royal Observatory, Greenwich:
1882, *March* 1.

Observations of Occultations of Stars by the Moon, and of Phenomena of Jupiter's Satellites, made at the Radcliffe Observatory, Oxford, in the year 1881. By E. J. Stone, Esq., M.A., F.R.S.

Occultations of Stars by the Moon.

Day of Observation.	Phenomenon.	Instrument.	Moon's Limb.	Greenwich Mean Solar Time of Observation.	Observer.
				h m s	
1881, September 3 (*a*)	Disapp. of ξ^2 Sagittarii	10-foot Equatoreal	Dark	10 16 21·3	W.
	,, ,,	42-inch telescope	,,	10 16 21·5	R.
October 11 (*b*)	Reapp. of 105 Tauri	10-foot Equatoreal	,,	17 6 35·7	R.
14 (*c*)	Reapp. of *f* Geminorum	42-inch telescope	,,	13 56 52·8	R.
November 29 (*d*)	Disapp. of 16 Piscium	10-foot Equatoreal	,,	5 14 39·8	W.
December 5 (*e*)	Disapp. of ι Tauri	42-inch telescope	Full	6 23 57·5	W.
(*f*)	Reapp. of ι Tauri	,,	,,	7 25 7·5	W.

Observers' Remarks.

(*a*) and (*d*) Instantaneous. (*b*) Reappeared instantaneously. (*c*) Reappeared instantaneously, but bad image.
(*e*) Moon partially eclipsed. Limb very sharp; observation good. (*f*) Star's image diffused; so time noted may be a very little late.

Phenomena of Jupiter's Satellites.

Day of Observation.	Satellite.	Phenomenon.	Instrument.	Greenwich Mean Solar Time of Observation. h m s	Greenwich Mean Solar Time of *N.A.* h m s	Observer.
1881, August 24 (*a*)	III.	Tr. Ingr. Ext. contact	42-inch telescope	12 38 30		
		Bisection	,,	12 43 30±	12 46	R.
		Int. contact	,, ,,	12 53 30		
September 19 (*b*)	II.	Occ. Reapp. First seen	,,	10 36 8		
		Bisection	,,	10 41 20±	10 38	R
		Ext. contact	,,	10 45 19		
21 (*c*)	I.	Tr. Ingr. Ext. contact	,,	11 35 1		
		Bisection	,,	11 38 6	11 40	R.
		Int. contact	,,	11 42 20		
29 (*d*)	III.	Tr. Egr. Int. contact	,,	8 38 53		
		Bisection	,,	8 42 32	8 43	R.
		Ext. contact	,,	8 46 51		
29 (*e*)	I.	Ecl. Disapp. First dim. of brightness	,,	9 32 34	9 34 27	R.
		Disappearance	,,	9 34 53		
30	I.	Tr. Egr. Int. contact	,,	9 58 57		
		Bisection	,,	10 2 27	10 5	R.
		Ext. contact	,,	10 5 26		

Day of Observation.		Satellite.	Phenomenon.	Instrument.	Greenwich Mean Solar Time of Observation. h m s	Greenwich Mean Solar Time of *N.A.* h m s	Observer.
October	3 (*f*)	II.	Ecl. Disapp. First diminution	42-inch telescope	10 54 11	10 55 7	R.
			Last seen	,,	10 55 53		
	14 (*g*)	I.	Tr. Ingr. Ext. contact	10-foot Equatoreal	11 22 38	11 26	R.
			Bisection	,,	11 25 47		
			Int. contact	,,	11 30 37		
	14 (*h*)	I.	Tr. Egr. Int. contact	,,	13 29 27	13 37	R.
			Bisection	,,	13 33 47		
			Ext. contact	,,	13 37 31		
	15 (*i*)	I.	Ecl. Disapp. First diminution	42-inch telescope	7 49 43	7 51 33	W.
			Half brightness	,,	7 50 38		
			Disappearance	,,	7 51 34		
	29 (*k*)	I.	Ecl. Disapp. First diminution	10-foot Equatoreal	11 39 1	11 40 41	W.
			Half brightness	,,	11 40 1		
			Disappearance	,,	11 41 9		
November	22 (*l*)	I.	Tr. Ingr. Ext. contact	,,	8 52 52	8 55	W.
			Bisection	,,	8 55 6		
			Internal contact	,,	8 57 34		
	22 (*l*)	I.	Tr. Egr. Int. contact	,,	11 4 18	11 7	W.
			Bisection	,,	11 6 24		
			Ext. contact	,,	11 8 32		

Day of Observation.	Satellite.	Phenomenon.	Instrument.	Greenwich Mean Solar Time of Observation. h m s	Greenwich Mean Solar Time of *N.A.* h m s	Observer.
1, November 23 (*m*)	I.	Ecl. Reapp. First appearance	10-foot Equatoreal	8 30 38	8 30 56	W.
29 (*n*)	II.	Ecl. Reapp. First seen	„	10 8 37		
		Half brightness	„	10 9 52	10 9 1	W.
		Full brightness	„	10 10 57		
December 7 (*o*)	I.	Occ. Disapp. First contact	„	9 31 12		
		Bisection	„	9 33 43	9 35	W.
		Last seen	„	9 36 5		

10-foot Equatoreal. Power = 180. 42-inch Telescope. Power = 100.

The initials W. and R. are those of Mr. Wickham and Mr. Robinson respectively.

Observers' Remarks.

(*a*) Cloudy at times. (*b*) Observation fair. (*c*) Good images. (*d*) Observation good. (*e*) Satisfactory observation.
(*f*) Satellite followed continuously until $10^h\ 55^m\ 50^s$, and at the time noted "last seen" ($10^h\ 55^m\ 53^s$) it appeared for a moment, as the faintest possible point, and then vanished. Good observation.
(*g*) Limb of planet tremulous at times. (*h*) Limb of planet not well defined at times.
(*i*) Observation difficult, owing to bad image. (*k*) Observation good. (*l*) Images ill defined.
(*m*) Observation considered good, but images diffused. (*n*) and (*o*) Observations good.

Note on the North Polar Distance of the Star Lacaille 4342. By David Gill, Esq., H.M. Astronomer at the Cape of Good Hope.

In his Paper on the North Polar Distances of the Cape Catalogue (*Monthly Notices*, November 1881), Mr. Downing, at page 20, directs my attention to the star Lacaille 4342, pointing out a discordance of 4″·69 between its N. P. D. as given in the Cape Catalogue for 1880 and that of the Melbourne Catalogue for 1870.

The discordance, however, is capable of easy explanation—viz. a typographical error in the Melbourne Catalogue.

The mean of the separate results, as published in the annual volumes of the Melbourne Observatory, reduced to 1870, the N.P.D. of the Star in question appears to be about

$$176^\circ\ 16'\ 38''\cdot8,$$

not

$$176^\circ\ 16'\ 33''\cdot8,$$

as printed.

The place of the Cape Catalogue reduced to 1870 is

$$176^\circ\ 16'\ 38''\cdot5,$$

a sufficiently satisfactory agreement.

Note on the Places of Three Stars in the Armagh Catalogue. By Rev. T. R. Robinson.

Dr. Robinson's attention has been called (by M. L. Schulhof, of Paris) to three stars in this Catalogue of which the places appeared to be affected with errors.

On re-examining the observations and reductions, he finds this to be the case.

A 1435 : the A.R. and N.P.D. given there belong to different stars—the A.R. to P. vi. 61 ; the N.P.D. to P. 55, and when properly reduced becomes N.P.D. 31° 20′ 54″·87.

A 1437 : N.P.D. should be 31° 30′ 20″·53.

A 2076 : N.P.D. should be 90° 46′ 31″·86.

A New Method of Bright-wire Illumination for Position Micrometers. By S. W. Burnham, Esq.

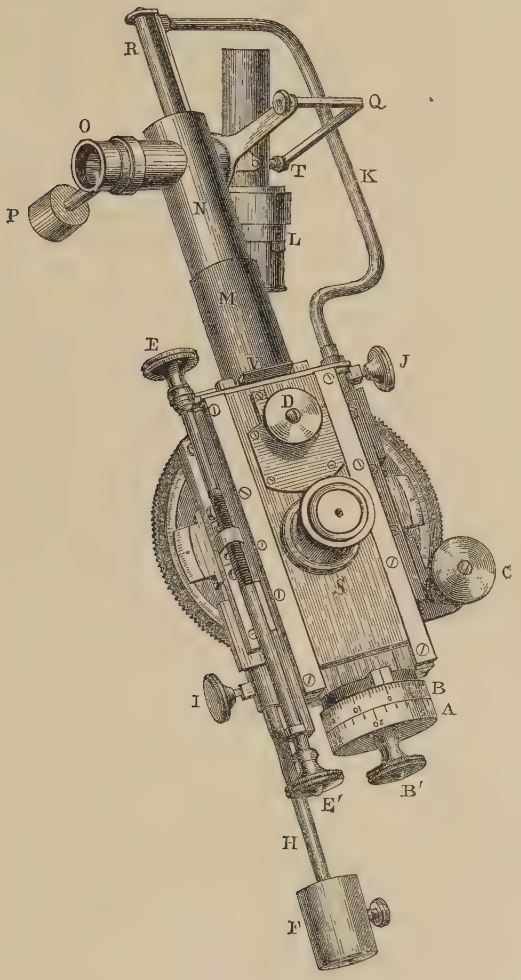
In all my double-star measures I have uniformly used a bright-wire illumination, that method having been found by experience to be much superior to any form of bright field, and

particularly in the observation of very close pairs and very faint companions which could only be seen with difficulty without any illumination at all. The Fraunhofer plan (which seems to have been the best in general use), of attaching the lamp to a hollow arm forming an angle of about 45° with the axis of the telescope, was always very objectionable and inconvenient, from the fact that to obtain a proper light on the wires it was necessary to change the place of the lamp with every change of the wires in position-angle, so as to allow the light to strike the wires approximately at right angles. For some years past I have given much attention, and made many experiments, with a view to the improvement of the micrometer in this respect. This resulted, while at the Washington Observatory during the summer of 1881, in the execution of a plan for the "end" illumination of the Clark micrometer attached to the 15½-inch Refractor of that Observatory. That device was fully described and illustrated in the *English Mechanic* for September 16, 1881. This micrometer was regularly used for some months, and although the illuminating apparatus was somewhat roughly made, and intended only to demonstrate the practical success of this device, it was found to work so satisfactorily in every respect that the micrometer for the 12-inch Refractor of the Lick Observatory was constructed after the same plan, and was used by the writer for some weeks on Mount Hamilton, Cal., in the latter part of 1881. This illuminating apparatus is identical in principle with that previously described, but, as would be expected from the great skill and ingenuity of the firm of Alvan Clark & Sons, by whom it was made, the mechanical construction generally is vastly improved, and the convenience and usefulness of the micrometer increased thereby.

The accompanying illustration is engraved from a photograph of the Lick Observatory micrometer, the construction of which will be understood by a brief description.

The micrometer is of the usual form made by the Clarks, B being the graduated head of the micrometer-screw, and A another graduated head turning on the same axis for giving the whole revolutions of the screw; C is the head of a pinion attached to the plate under the micrometer-box, and gearing into the teeth of the rigid circular plate containing the position circle, for moving the wires in position angle; D is the head of another small pinion for sliding the eyepiece over the wires; E E′ are heads of the bisecting-screw for moving the whole system of wires and the box S in a direction parallel to the micrometer-screw, and at right angles to the wires. The light from the lamp L is reflected by a mirror in N, and passes down that tube and through M, and then through a hole in the end of the box to the wires. A condensing lens is placed in N, for the purpose of concentrating the light on the wires. On the opposite side of the wires, towards the micrometer head, a small reflector is placed which reflects the light back, thereby symmetrically illu-

minating the wires on both sides. The lamp swings freely on its axis in the line of OT, but always maintains a vertical position, whatever may be the direction of the wires or the pointing of the telescope. The tube N, with the lamp and its



attachments, has an axle R supported by the fixed arm K. The bearings T, and axle of the lamp, are kept always horizontal by the weight of the counterpoise P. The tube M is fixed to the micrometer box, and projects loosely over N far enough to allow

for the necessary movement of the box by the bisecting-screw E. The supporting arm K is attached by the set-screw J, not to the box, but to the plate underneath it, so that the weight moved by the bisecting-screw is not increased at all by the illuminating apparatus. Attached to the same plate, on the opposite side by a set-screw I, is the rod H, bent so as to be thrown forward out of the way of E′ and B, with a weight F to balance the weight of the lamp attachments. The whole device can be instantly detached when desired, by loosening the screws I and J. In the tube M is a slot V, in which is placed a slip of red or other coloured glass, held in any desired place by a light spring pressing against it. All or any part of the light can be made to pass through the coloured medium. The mirror in N is attached to a tube which slides into the tube O. By turning this tube by the milled edge projecting at O, the inclination of the mirror may be varied to any extent, and the light reduced from the maximum amount until the wires become invisible. By turning the mirror 90° or more the light is entirely shut off. It will be seen that the lamp can revolve freely through the bent arm Q; and the whole moveable part of the device, lamp, arm Q, and counterpoise P, can turn through the supporting arm K, the lamp at all times remaining vertical, and in exactly the same position with respect to the wires. It might at first be supposed that the lamp, or some of the parts, would be in the way of the observer. I have never found it so in practice, and, although it is but a few seconds' work to either attach or detach it, I have very rarely removed it, whatever might have been the use of the telescope at the time.

It is important to preserve the relative positions of the micrometer-head, bisecting-screw, and pinion C, as here shown. No other arrangement will be as convenient. In every possible position of the micrometer, the necessary use of both hands at the same time will be found to be convenient and easy for the observer. Naturally the more delicate motions of the micrometer-screw and the pinion will be effected by the right hand, and the corresponding movement of the bisecting-screw by the left hand. When the micrometer box is anywhere near a horizontal position with respect to the observer (the wires at right angles to the line joining the eyes) C and E are used by the right and left hands respectively in measuring angles, and B′ and E in measuring distances. When the box is more nearly vertical with respect to the observer, the head E′ of the bisecting-screw will be worked by the left hand in each case. The convenience and practical value of this arrangement can only be appreciated by one who has used the old plans, and then tried this.

With respect to the practical working of the illumination, I will briefly say that it has proved a complete success in every respect. Any object that can be seen under any circumstances, however faint, can be well and accurately measured. There is no such thing as a star too faint for measurement, if it can be

seen at all. A very feeble light is sufficient to illuminate the wires perfectly for any object. I believe far better results can be obtained by the use of bright wires in a large part of the most desirable and important double-star work, than is possible by the same observer using a bright field, and that sooner or later it will be generally used in all micrometrical observations.

Chicago:
1882, *February* 25.

The Transit of Mercury, 1881, *November* 7, *observed in New South Wales.*

(*Communicated by H. C. Russell, Esq., Government Astronomer, Sydney.*)

In order to secure satisfactory observations of the Transit of *Mercury* the observers were divided into three parties: two, Mr. Lenehan, first assistant in the Observatory, and myself, observed at Sydney, using respectively $7\frac{1}{4}$-inch and $11\frac{1}{2}$-inch Refractors, both stopped to 6 inches. At Katoomba, a place on the Western Railway, 66 miles west of Sydney, and 3,400 feet above the sea level, Messrs. Hargrave and Bladen, assistants in the Observatory, observed; the former using a $4\frac{3}{4}$-inch Troughton & Simms equatoreally-mounted Refractor, and the latter a $4\frac{1}{4}$-inch Cooke Equatoreal, both driven by clock-work. At Bathurst, on the elevated table land, 2,300 feet above the sea and 134 miles by rail west of Sydney, the observers were Mr. Conder, chief of the Trigonometrical Branch of the Survey Department, and Mr. Brooks, on the Trigonometrical Survey staff; the former used a $4\frac{3}{4}$-inch Schroeder Equatoreal, and the latter a $3\frac{3}{4}$-inch Troughton & Simms.

The morning was fine and clear, but the definition in Sydney was very bad; on the high lands it was better. At Egress, the definition in Sydney was steadier, but a thick cirrus haze covered the sky; the conditions were similar at the inland stations, only the definition got worse instead of better.

The times given are all in Sydney mean time, and corrected for clock errors, but not for the positions of the observers. The following extracts from the observers' Reports will show the phenomena observed:—

Mr. Russell: "For *Ingress*, used $7\frac{1}{4}$-inch Merz Refractor, power 150.

"Air clear, but very unsteady. $8^h\ 21^m\ 34^s{\cdot}64$, thought I saw notch in Sun's limb, but lost it. $8^h\ 21^m\ 44^s{\cdot}64$, first contact certain. $8^h\ 23^m\ 5^s$, *Mercury* assumed a D shape; Sun's limb boiling, and *Mercury* seems to jump half its diameter. $8^h\ 23^m\ 39^s{\cdot}14$, observed unsatisfactory contact—unsatisfactory, because of the vibration and tremulous definition, and that, for ten seconds be-

fore, contact of limbs was made and broken several times over. From this time I used 11½-inch Schroeder Refractor, stopped to 6 inches, polarising eyepiece, no coloured glass, powers 100 to 200, made of quartz. In moments of best definition, see clearly the black specks in the mottling on the Sun's surface. *Mercury* intensely blue-black; no sign of satellite, and no halo of any kind visible round the planet; when definition gets bad, as it does periodically, *Mercury* loses the blackness, and looks like a black ball shaded with white, the darkest part of the shading being near the planet's limb; thence, shading off to nothing before it reaches the centre, it extends half-way round the planet on the preceding side; I see no white spot in the centre. *Egress*: Definition steadier, but very thick haze. At $1^h\ 40^m\ 55^s$, Sun very unsteady, a shade or dark band connected the limbs, then broke; this was repeated several times in as many seconds, and then ceasing left a clear band of light between the limbs. Definition steady, band of light got gradually narrower, and broke at $1^h\ 40^m\ 26^s{\cdot}65$; ten seconds later planet elongated. Clouds thick, obliged to turn polarising eyepiece to admit all the light it would; last contact observed at $1^h\ 42^m\ 8^s{\cdot}95$. Nothing seen of the planet after this; haze too thick."

Mr. Lenehan: "*Ingress* observed through 3-inch Refractor, hurriedly placed in position and moved by hand-screw. First indent, $8^h\ 22^m\ 8^s$. Planet moved steadily and clearly on towards internal contact, which was observed at $8^h\ 23^m\ 43^s$. Observations now made with 7¼-inch Merz, stopped to 6 inches. At $8^h\ 5^m$ an apparent halo round planet. $9^h\ 6^m$, halo still visible. $9^h\ 50^m$, disk of planet sharp, without marginal indistinctness or halo; no appearance of any satellite; clouds about. $10^h\ 50^m$, clear disk, halo not discernible. *Egress*: $1^h\ 10^m$, definition bad, with marginal indistinctness. First contact at Egress, $1^h 40^m\ 29^s{\cdot}25$; no absolute certainty in the actual time, as the definition was not good and the wind high, causing vibration in the telescope, but I am satisfied with the time given. External contact occurred under same conditions at $1^h\ 42^m\ 4^s{\cdot}25$."

Dr. Wright obtained time from the Observatory, and observed with his own 8½-inch Reflector: for Ingress stopped to 5 inches, power 80; for Egress stopped to 7½ inches. Browning's double-prism solar eyepiece used.

Mr. Morrice used his own 8½-inch Browning-With Reflector; obtained time from the Observatory, and observed in the suburbs of Sydney.

KATOOMBA.

Mr. Hargrave: "Weather all that could be wished. Used full aperture, 4¾ inches; power 100; darkest glass shade. Definition very good. Saw first contact at $8^h\ 22^m\ 0^s{\cdot}66$, Sydney mean

time. Planet three-quarters on, cusps slightly rounded, but it did not last until second contact, when the definition was very good and quite calm. At $8^h\ 23^m\ 41^s{\cdot}38$, there is an optical illusion like a spot of light in the centre of *Mercury*, which disappears on looking steadfastly at it; the limb of *Mercury* is a hard line, no colour or difference of light on the Sun at the planet's limb. $8^h\ 43^m$, cirrus clouds about. $9^h\ 21^m$, tried high power—definition bad, it is shaky with low one too; reduced aperture to 2 inches —much better definition. White spot still dancing about the middle of *Mercury*; blackness of planet more intense than that of Sunspot. $12^h\ 25^m$, white spot very persistent. $1^h\ 35^m$, light clouds passing. Observed internal contact at $1^h\,40^m\,10^s{\cdot}4$, both limbs moderately well defined, cusps sharp; last contact at $1^h\ 42^m\ 0^s{\cdot}09$."

Mr. Bladen: "Weather very clear. Used $4\frac{1}{4}$-inch Cooke Equatoreal, with clock-work, solar diagonal eyepiece, power 100; object-glass stopped to 2 inches. Definition very good indeed. First contact, slight indent, at $8^h\ 22^m\ 3^s{\cdot}34$; outline of planet as it crept on the Sun very clear and well defined. When planet was three-quarters on, a light cirrus cloud passed, making cusp indistinct; and at $8^h\ 23^m\ 24^s{\cdot}64$, I thought, from the irregular shape of *Mercury*, that internal contact would be complete but for the bad definition. At $8^h\ 23^m\ 42^s{\cdot}84$ a band of light was visible between the limbs, and from its breadth it would doubtless have been seen two or three seconds before with better definition.

"No sign of the part off the Sun's disk could be seen during the time *Mercury* was creeping on the Sun. *Mercury* on the Sun appears a perfect sphere and intensely black, without any halo or spots, and I saw no satellite. Definition so good for an hour after Ingress that I used the highest powers, and different apertures, but I could see nothing else to note.

"*Egress*: Internal contact, $1^h\ 40^m\ 44^s{\cdot}34$. I waited before taking this time until I was quite sure contact was complete, the bad definition making it difficult to decide. The planet did not seem to move steadily off the Sun, but in a series of jumps half a second in duration, which may have lasted ten or fifteen seconds; when I was quite certain that there was no trace of the planet, I noted the time, $1^h\ 42^m\ 23^s{\cdot}64$."

Bathurst.

Mr. Conder: "I used $4\frac{3}{4}$-inch Schroeder telescope, equatoreally mounted; solar eyepiece and power 90 were used. Tried various stops, and then used full aperture of objective. Having an electric chronograph, ticks of Sydney standard clock were recorded, beside those of my chronometer, a short time before and after transit, and errors of time were thus practically eliminated.

"In early morning weather very fine, but about time of Ingress

clouds (cirrus) began to form, but definition was very good. My driving clock was not working well, so that specks of dust were made to move and caused apparent notches on the Sun's limb, and for a second or two I was in doubt, but as soon as I was certain I closed the chronograph key, and made the time $8^h\ 22^m\ 5^s$. Comparing mentally afterwards the distance between the cusps, I estimated this at six or seven-tenths of the planet's diameter; but as the estimate was not made at the time, it is not intended to be used. A few seconds before internal contact the telescope was accidentally touched, causing vibrations, which had scarcely ceased when the limbs of the planet and Sun appeared tangential; time by chronograph, $8^h\ 23^m\ 35^s{\cdot}75$. I felt in some doubt whether the cusps had really closed at this instant, and I continued to watch very carefully, and, within so small an interval as to be scarcely appreciable, an extremely fine line of light was noticed separating the planet from the Sun's limb.

"I watched the planet at intervals during its transit, the definition most of the time being magnificent. I failed to notice any peculiar appearances, except, perhaps, a very faint suspicion of a halo, or yellowish light surrounding the intensely black disk of the planet, and slightly brighter than the general illumination of the Sun's disk; this I attributed to an optical illusion.

"At Egress, clouds were so thick that I could not see the Egress through my dark glass, and I had not a second one.

"The position of the observing station, found by connection with the main triangulation, is—Lat. 33° 25′ 45″·5; Long. 149° 33′ 47″·9 East."

Mr. Brooks: "Telescope used was by Troughton & Simms, $3\frac{3}{4}$-inch aperture, and equatoreally mounted, stopped to 3 inches; solar reflecting eyepiece, and power 104, with lighter of the two coloured shades. The definition on Sunspots was very clear, and the whole of the Sun's surface had a faint mottled appearance, and the faculæ were at times very distinct. Three or four minutes before contact cirrus clouds covered the sky. I first caught sight of a decided notch in the Sun's limb at $8^h\ 22^m\ 3^s{\cdot}60$; the notch was quite decided before I was certain it was what I was looking for. On reflection, I think about one-tenth of the planet's disk must have been on the Sun at the time. At $8^h\ 23^m\ 36^s{\cdot}45$ I caught the first indication of a white line separating the Sun and planet's limbs. Just before this, the planet seemed to draw out slightly, as if unwilling to leave the Sun's limb, leaving in my mind a faint suspicion of a black drop. Three minutes after contact I saw a whitish spot on the south preceding quadrant, and an irregular white band of light inside the planet's disk. I suspect this was merely optical. About noon clouds were denser, causing the planet to lose its dead black appearance. Definition fairly steady. Ten minutes before Egress I changed the eyepiece for one marked 110, aperture and sunshade as before. At $1^h\ 40^m\ 26^s{\cdot}48$, I noted first internal

contact, without seeing any indication whatever of the black drop; and at $1^h\ 42^m\ 8^s{\cdot}59$ I saw the last contact; but owing to the passing clouds, there may be an uncertainty of, say, one second in first and about two seconds in last contact at Egress. Time by chronometer compared before and after transit with ticks from Sydney clock."

Observed Times of Transit of Mercury in New South Wales.

	First External Contact.	First Internal Contact.	Second Internal Contact.	Second External Contact.
	h m s	h m s	h m s	h m s
Russell	8 21 44·64	8 23 39·14	1 40 26·65	1 42 8·95
Lenehan	22 8·00	43·00	29·25	4·25
Wright	21 20·00	10·00	23·00	3·00
Morrice	22 15·00	46·00	16·00	16·00
Hargrave	22 0·66	41·38	10·40	0·09
Bladen	22 3·34	42·84	44·34	23·64
Conder	22 5·00	35·75	—	—
Brooks	22 3·60	36·45	26·48	8·59
Arithmetical Means	8 21 57·53	8 23 36·82	1 40 25·16	1 42 9·217

Observations of the Transit of Mercury, 1881, November 7, made at Honolulu, Sandwich Islands. By C. H. Rockwell, Esq.

(*Communicated by the Secretaries.*)

I send herewith a Report of my movements in connection with observations made of the Transit of *Mercury*, at Honolulu, Sandwich Islands, on November 7, 1881.

The king, Kalakaua, offered me the free occupancy of the site from which the observations of the Transit of *Venus* were made in December 1874 by the English party under command of Capt. G. L. Tupman.

This civility on the part of His Majesty saved me the trouble and expense of building a pier of mason-work on which to mount my telescope, and, being on his own private grounds, I was enabled to occupy a quiet location whose geographical position had been determined with great accuracy.

The latitude and longitude given in this Report, and used in computing the times of contact, are the results obtained by Capt. Tupman.

I built a shed of rough boards over one of the piers left by the Transit of *Venus* party; there was no roof on the slope towards the South and West, the opening being covered at night with a part of an old sail, which could be easily put in position or withdrawn.

I set up the telescope in this temporary observatory on November 4, and during the 5th and 6th brought the instrument into proper adjustment.

The morning of the 7th was cloudy, and the prospects of success not very encouraging. The clouds passed away from the zenith, however, before the time of first contact, which was about 11.45 A.M., local mean time.

Astronomically speaking, the day was not perfect, nor even first-rate; still it was very good indeed, and I consider my work, on the whole, as having been highly successful.

In making my observations I used the full aperture of the glass, $6\frac{1}{3}$ inches, with a first surface solar prism, by Alvan Clark & Sons, and an eyepiece of power 60.

Twice during the day I used a power of 130, but for a few minutes only, as I found the increased size of the image was gained at the sacrifice of clearness of definition.

The intensely black disk of the planet was in strong contrast with a Sun-spot of considerable size, which was seen on the face of the Sun quite near to the point of second contact.

After having recorded the time of first and second contact, the telescope was moved in R. A. a little in advance of the Sun, and there clamped.

The time was then taken from the chronometer, when the advancing limb of the Sun, a large Sun-spot, the planet *Mercury*, and the following limb crossed the centre wire of the eyepiece: this being set at 90° to the line of the Sun's motion in the parallel, by allowing the Sun's limb to move along it.

I took about ninety of these combined observations, a copy of the record being appended to this Report.

At times during the continuance of the Transit the sky was free from clouds in the vicinity of the Sun, and the definition very satisfactory.

The spherical form of the planet was easily noticed; the edges of his disk sharp and clean, without any *fuzziness* or wavy outline to indicate the existence of an atmosphere.

I took advantage of these favourable moments to look carefully over the whole disk of the Sun, searching for anything which might look like an intra-Mercurial planet. I failed, however, to detect any such indications, although, from the clearness with which the *rice-grains* were shown, I am confident I could have detected the presence of any opaque body having one-tenth the diameter of *Mercury*. Nor did I at any time see any spots on the disk of the planet.

At the time of third and fourth contacts the Sun was only about twenty minutes above the horizon.

I could still see the planet distinctly, but the haze lying along the horizon caused a violent *boiling* of the edges of the Sun's disk, and the planet seemed to be dancing, or tossed about like a chip floating on the surface of broken water.

Three times I called to the recorder to *mark* the instant of

third contact, supposing the planet to have reached the edge of the disk; again and then again I saw a strip of light in advance of the moving body, each time calling to *mark*.

The unfavourable atmospheric conditions at this phase would allow but little weight to be given to an opinion as to the existence of the *black-drop* phenomenon. I can say, however, quite positively, that no such appearance presented itself to me.

The whole disk of the planet seemed to be thrown towards the edge of the Sun, and then to rebound; but the advance and receding were well defined.

The form of the disk was distorted, but the edges were clean and sharp up to the moment when third contact was last called.

I attach but little value to the time given as fourth contact, it simply records the last glimpse which I had of the Transit of November 1881.

I give the computed and observed times of contacts below:—

Contacts.	Computed *Nautical Almanac.*	Computed *American Ephem.*	Observed G.M.T.
1st	10 16 29·79	10 16 23·01	10 17 27·25
2nd	10 18 12·62	10 18 05·84	10 18 25·75
3rd	15 35 21·77	15 34 39·66	15 35 36·25
4th	15 37 04·79	15 36 22·68	15 36 28·25

Transit of Mercury at Honolulu.

Lat. 21° 17′ 56″·3 North; Long. 10^h 31^m 27·3 West of Greenwich.

Chronometer: Negus, No. 1305. Correction $+38^s·25$.

First contact 10 16 49 by Chronometer.

Second contact 10 17 47·5 „

Sun's Advancing Limb.	Sun-spot.	Diff.	*Mercury* (centre)	Diff.	Sun's Following Limb.	Diff.
h m s	h m s	m s	h m s	m s	h m s	m s
10 19 58·5			10 21 56	1 57·5	10 22 12	2 13·5
22 59	10 24 12	1 13	24 56	57	25 14·5	15·5
26 44·5	27 57·5	13	28 39·5	55	28 59·5	15
29 38	30 51	13	31 31·5	53·5	31 52·5	14·5
32 23·5	33 37	13·5	34 17	53·5	34 39	15·5
35 00·5	36 13·5	13	36 53	52·5	37 15·5	15
37 45	38 57·5	12·5	39 35·5	50·5	39 59·5	14·5
40 22	41 34	12	42 11	49	42 36	14
42 49·5	44 01·5	12	44 38	48·5	45 04	14·5
45 31·5	46 44	12·5	47 20·5	49	47 46·5	15

Sun's Advancing Limb.	Sun-spot.	Diff.	*Mercury* (centre)	Diff.	Sun's Following Limb.	Diff.
h m s	h m s	m s	h m s	m s	h m s	m s
Passing clouds.						
11 05 29·5	11 06 42·5	1 13	11 07 10·5	1 41	11 07 44·5	2 15
08 16	09 29	13	09 56	40	10 31·5	15·5
10 52	12 05	13	12 31	39	13 07	15
13 37	14 49	12	15 15	38	15 52	15
16 15	17 28	13	17 52·5	37·5	18 31	16
18 52	20 04·5	12·5	20 28	36	21 07	15
21 28	22 40	12	23 03	35	23 43	15
24 12	25 24	12	25 46	34	26 27	15
26 40·5	27 53·5	13	28 14	33·5	28 57·5	17
29 20	30 32	12	30 52·5	32·5	31 35·5	15·5
38 18	39 30	12	39 47·5	29·5	40 33	15
41 14·5	42 25·5	11	42 43	29	43 29	14·5
44 40	45 52	12	46 08	28	46 55	15
47 18	48 29·5	11·5	48 44·5	26·5	49 32·5	14·5
50 43	51 54·5	11·5	52 08	25	52 58	15
53 29	54 40	11	54 52·5	23·5	55 43·5	14·5
56 24·5	57 36	11·5	57 47	22·5	58 39·5	15
59 07	12 00 18·5	11·5	12 00 29	22	12 01 22	15
12 02 12·5	03 24	11·5	03 33·5	21	04 27·5	15
04 54·5	06 06	11·5	06 14	19·5	07 09	14·5
07 45			09 04	19		
11 09·5	12 19·5	10	12 26	16·5	13 23	13·5
14 05	15 17	12	15 22·5	17·5	16 20·5	15·5
17 11	18 22	11	18 26	15	19 25·5	14·5
19 52	21 03	11	21 06	14	22 06·5	14·5
22 27	23 38	11	23 40	13	24 42	15
25 13·5	26 25	11·5	26 26	12·5	27 28·5	15
28 00	29 11	11	29 11	11	30 15	15

Mercury passes the Sun-spot.

Sun's Advancing Limb.	*Mercury* (centre)	Diff.	Sun-spot.	Diff.	Sun's Following Limb.	Diff.
h m s	h m s	m s	h m s	m s	h m s	m s
12 37 19	12 38 26·5	1 07·5	12 38 29·5	1 10·5	12 39 34	2 15
39 53·5	41 00·5	07	41 05	11·5	42 09	15·5
42 24·5	43 30	05·5	43 35·5	11	44 39	14·5

Sun's Advancing Limb.	*Mercury* (centre)	Diff.	Sun-spot.	Diff.	Sun's Following Limb.	Diff.
h m s	h m s	m s	h m s	m s	h m s	m s
12 45 08·5	12 46 14	1 05·5	12 46 20	1 11·5	12 47 24	2 15·5
49 22	50 25	03	50 33	11	51 37	15
51 56			53 06·5	10·5	54 11	15
54 42	55 43·5	01·5	55 53·5	11·5	56 57·5	15·5
57 14	58 14	00	58 25	11	59 29	15
59 48	1 00 47·5	0 59·5	1 00 59	11	1 02 03·5	15·5
1 02 38·5	03 37	58·5	03 49·5	11	04 54·5	16
05 30	06 27	57	06 40·5	10·5	07 45	15
08 06·5	09 03·5	57	09 17·5	11	10 21·5	15
11 11	12 06	55	12 12	11	13 26	15
14 12·5	15 06	53·5	15 23	10·5	16 27	14·5
16 57	17 49·5	52·5	18 07·5	10·5	19 12	15
19 43·5	20 35	51·5	20 54·5	11	21 58	14·5
22 57·5	23 48	50·5	24 08·5	11	25 12·5	15
25 47	26 37·5	50·5	26 58	11	28 02·5	15·5
28 43	29 31·5	48·5	29 53·5	10·5	30 58	15
31 45	32 33	48	32 56	11	34 00·5	15·5
35 30·5	36 17	46·5	36 41·5	11		
39 48·5						
40 14·5	40 58·5	44	41 25	10·5	42 30	15·5
42 42·5	43 26·5	43·5	43 54	11·5	44 58·5	16
45 42	46 23·5	41·5			47 56	14
48 43		Passing clouds.				
2 01 05	2 01 41	36				
15 44	16 13	29	2 16 52	08		
18 43	19 12	29	19 52·5	09·5	2 20 57·5	14·5
22 42·5	23 11	28·5	23 51·5	10	24 56·5	14
25 21	25 48	27	26 30	09	27 36	15
28 26·5	28 52·5	26	29 36	09·5	30 41·5	15
31 01·5	31 27	25·5	32 11·5	10	33 16·5	15
33 31	33 55	24	34 40·5	09·5	35 45·5	14·5
36 30	36 53·5	23·5	37 40·5	10	38 45·5	15·5
39 27	39 49	22	40 36·5	09·5	41 42·5	15·5
42 04	42 24·5	20·5	43 14	10	44 19	15
45 06	45 26	20	46 16	10	47 21	15
47 42·5	48 01	18·5	48 51·5	09	49 57·5	15
50 13	50 31	18	51 23	10	52 29	16

Sun's Advancing Limb.	*Mercury* (centre)	Diff.	Sun-spot.	Diff.	Sun's Following Limb.	Diff.
h m s	h m s	m s	h m s	m s	h m s	m s
2 52 46	2 53 03	0 17	2 53 55	1 09	2 55 01	2 15
55 40·5	55 56·5	16	56 50	09·5	57 56	15·5
58 29			59 38	09	3 00 44	15
3 01 01·5	3 01 15	13·5	3 02 10·5	09	03 16	14·5
04 00·5	04 13	12·5	05 10	09·5	06 16	15·5
07 08·5	07 19 5	11	08 17 5	09	09 23·5	15
10 00	10 10	10	11 09	09	12 14·5	14·5
12 58·5	13 07	08·5	14 08	09 5	15 13·5	15
15 36	15 44	08	16 45	09	17 51	15
18 14	18 21	07	19 23	09	20 29	15
21 00	21 06	06	22 09·5	09·5	23 15·5	15·5
24 03	24 08	05	25 11·5	08 5	26 17·5	14·5

Third contact 3 34 58 by Chronometer.

Fourth contact 3 35 50 „

Tarrytown, New York:
1881, *December.*

[*Notes on the Lunar Eclipse*, 1881, *December* 5.

By J. Rand Capron, Esq.

Though the Moon rose eclipsed at $3^h\ 50^m\ 0^s$ G. M. T. it was, owing to slight banks of clouds on the horizon, not until $5^h\ 3^m$ that it was seen from this locality. At that time it presented an interesting aspect, a small portion only being left uncovered. The opposite side of the disk to this glowed with a distinct, but not deep, red tint. This gradually melted into a golden tint, and finally into a pearly grey as it approached the bright part of the Moon. The uncovered part gradually got narrower, and at $5^h\ 10^m$ ($5^h\ 8^m\ 0^s$ at Greenwich) was considered to be at its narrowest. No red patches or brilliant tints were seen, but the Moon's configuration was well made out through the shadow. In the $3\frac{1}{4}$-inch Cooke, power 50, the general appearance of the tinted globe, with its faint edging of partial light, was very charming. As the shadow passed off, the red tint was gradually lost, until when about two-thirds of the disk were uncovered it was not longer recognisable.

Throughout the eclipse it was noticed that the lighted portion of the Moon was very much softened into the obscured part without definite outline; and also that there was difficulty in distinguishing any boundary between the umbra and the pen-

umbra on the disk. The Moon was, however, low and the night misty. The occultation of *ι Tauri* was seen at about the time given for it, but the "boiling" of the Moon's limb rendered any time observation valueless. Five photographs were taken, with the 6″ Equatoreal, of the gradual passing-off of the shadow, and I present with this paper prints from the enlargements. There should have been six, but one image was by mistake duplicated. The sixth place is filled by a photograph of the Moon showing the ordinary appearance of its bright edge.

Observatory, Guildown:
1882, *January* 24.

Observations of Comet III. 1881, *made at Windsor, New South Wales.* By John Tebbutt, Esq.

This comet was very difficult to observe. I detected it while sweeping for comets with a $3\frac{1}{4}$-inch Refractor on the evening of September 17. It was then invisible to the unassisted eye, and presented the appearance of an oval nebula, with a very gradual condensation towards the centre. On the evening of the 19th its aspect was greatly changed. It was the only evening on which there was anything like a central condensation with tolerably defined limits. There were also rudiments of a tail. From this date the comet became rapidly fainter, and during the last few days of its visibility it could be observed only by looking obliquely into the telescope. At no time would it bear a field illumination sufficiently strong to exhibit the spider lines of the filar micrometer. I was therefore compelled to employ the ring micrometer on the $4\frac{1}{2}$-inch telescope. The differential North Polar Distances for September 17, 18, 19, 30, and October 14, are unsatisfactory, owing to the near approach of the objects to the ring's centre. The mean places of the stars of comparison, where taken from the Washington Catalogues for 1872 and 1874, and the Sydney Catalogue for 1878, have been brought up to 1881·0 by means of the catalogue precessions. In all other cases the total precessions to 1881·0 have been derived from the annual precessions calculated for the mean dates by means of Peters's elements. Proper motion has been applied to the places of stars Nos. 11 and 14 only. For the parallax factors p denotes the corrections in seconds of time and arc for the Right Ascension and North Polar Distance respectively, and Δ the comet's distance from the Earth. The equatoreal horizontal parallax of the Sun has been assumed $8''{\cdot}85$.

I may add that with the help of M. Backlund's Ephemeris, received from St. Petersburg, I have sought for Encke's Comet,

but in vain. When the comet was sufficiently south, and removed from the morning twilight, it was considerably beyond the grasp of my telescope.

Apparent Places of Comet III. 1881.

	Windsor Mean Time 1881.	R.A.	Log ($p\Delta$)	N.P.D.	Log ($p\Delta$)	No. of Comps.	Comp. Star.
	d h m s	h m s	+	° ′ ″	+		
Sept.	17 7 59 12	14 26 5·95	9·6994	104 44 41·9	0·6411	3	1
	17 8 23 14	14 26 7·25	9·7052	—	—	7	2
	17 8 42 22	14 26 8·50	9·7063	—	—	3	1
	18 7 15 56	14 27 40·25	9·6797	105 36 3·0	0·6015	2	3
	18 8 6 50	14 27 43·78	9·7041	—	—	3	3
	19 7 26 20	14 29 13·20	9·6898	106 26 9·5	0·6075	7	4
	20 7 27 2	14 30 40·05	9·6935	107 13 32·1	0·6055	8	5
	26 7 53 31	14 37 55·65	9·7199	111 9 31·9	0·6309	7	6
	29 7 43 28	14 40 53·28	9·7245	112 44 26·9	0·6222	5	7
	29 8 13 41	14 40 54·14	9·7268	—	—	4	8
	30 7 55 15	14 41 48·24	9·7282	113 13 39·8	0·6391	4	9
Oct.	1 7 49 25	14 42 41·92	9·7294	113 41 19·5	0·6337	5	10
	2 7 38 3	14 43 34·70	9·7298	114 8 7·6	0·6206	7	11
	3 7 55 41	14 44 24·82	9·7330	114 34 15·9	0·6467	5	12
	4 7 33 38	14 45 13·82	9·7330	114 58 59·9	0·6191	2	13
	5 7 44 51	14 46 3·28	9·7360	115 23 50·8	0·6374	5	14
	8 7 33 9	14 48 22·99	9·7399	116 31 24·0	0·6297	3	15
	12 7 53 59	14 51 19·80	9·7424	117 54 5·5	0·6732	3	16
	12 7 53 59	14 51 19·85	9·7424	—	—	3	17
	14 7 46 22	14 52 45·80	9·7453	118 32 31·3	0·6699	3	18
	15 7 34 33	14 53 24·94	9·7481	118 50 42·6	0·6565	4	18

Mean Places of the Comparison Stars for 1881·0, *with the Reductions to the Apparent Places for the Dates of Observation.*

Comp. Star.	Mean R.A.	Reduction. +	Mean N.P.D.	Reduction. +	Authority for Star's Mean Place.
	h m s	s	° ′ ″	″	
1	14 23 43·65	2·50	104 43 11·0	11·1	Lalande, 26453.
2	14 22 42·40	2·49	104 51 29 2	11·2	Lalande, 26425.
3	14 17 26·17	2·47	105 33 34·4	11·5	Arg. Oeltzen. S. Z. 13587 and 8.
4	14 27 28·95	2·52	106 17 42·5	11·2	Arg. Oeltzen. S. Z. 13727.
5	14 32 46·15	2·55	107 22 17·6	11·2	Arg. Oeltzen. S. Z. 13793, 4, 5, and 6.

Comp. Star.	Mean R.A. h m s	Reduction. + s	Mean N.P.D. ° ′ ″	Reduction. + ″	Authority for Star's Mean Place.
6	14 33 6·50	2·55	111 9 34·8	11·7	Arg. Oeltzen. S. Z. 13801.
7	14 35 34·22	2·55	112 54 56·5	11·7	Arg. Oeltzen. S. Z. 13848, 49 and 50.
8	14 39 16·99	2·57	112 38 50·1	11·5	Arg. Oeltzen. S. Z. 13909.
9	14 44 22·72	2·60	113 21 53·7	11·4	Arg. Oeltzen. S. Z. 13987, and 9.
10	14 47 0·80	2·60	113 29 11·3	11·2	Wash. Gen. Cat. 1860, 6118.
11	14 47 25·68	2·61	114 9 15·7	11·3	Wash. Gen. Cat. 1860, 6123.
12	14 37 44·49	2·56	114 32 36·4	11·6	Arg. Oeltzen. S. Z. 13885.
13	14 41 35·10	2·58	114 59 42·9	11·5	Wash. Gen. Cat. 1860, 6086.
14	14 40 48·09	2·57	115 35 17·1	11·6	Wash. Gen. Cat. 1860, 6082, and Sydney Cat. 1878, 170.
15	14 49 59·44	2·61	116 19 10·4	11·1	Wash. Gen. Cat. 1860, 6133.
16	14 46 43·46	2·60	117 55 3·4	11·1	Wash. Gen. Cat. 1860, 6117.
17	14 47 17·90	2·60	117 51 39·6	11·1	Wash. Gen. Cat. 1860, 6121.
18	14 50 7·83	2·62	118 40 30·8	11·0	Wash. Gen. Cat. 1860, 6135, Wash. Obs. 1872, 396, and Wash. Obs. 1874, 199.
18	14 50 7·83	2·62	118 40 30·8	10·9	,, ,,

Windsor, N. S. Wales:
1881, *December* 22.

Comet b, 1881, *as seen from the Ship "Superb."* By D. W. Barker, Esq.

(*Communicated by Capt. Henry Toynbee, R.N.*)

Date	G.M.T.	Lat.	Long.	Bar.	Att. Ther.	Air Ther.	Remarks on Position, etc.
	h m						
May 29	7 17	36° 34′ S.	2° 10′ W.	30·268	56·2	55·5	First seen to S.W. of Canopus and Sirius. Fine bright nucleus comparable with β Columbæ, perhaps a shade brighter, round and well defined. Tail about 6° long, slightly inclined to S. of line joining nucleus and Canopus. Generally well defined. Distance from Sirius 26° 42′ 45″.
June 2	5 53	40 21 S.	7 32 E.	30·582	52·5	48·0	Nucleus bright as α Columbæ. Tail faintly traceable to and slightly W. of o Columbæ, which was situated just on edge.
							Distance from Canopus 28° 51′ 15″ „ Sirius 24 43 0 „ Procyon 48 51 30
3	5 48	41 4 S.	9 31 E.	30·745	53·5	49·0	Slightly brighter. Tail extending to o Columbæ. Showing well.
							Distance from Canopus 29° 54′ 0″ „ Sirius 24 9 0 „ Procyon 48 1 0
4	5 33	41 12 S.	11 30 E.	30·663	52·5	50·0	Clearer and better defined. Tail longer, stretching to o Columbæ.
							Distance from Canopus 31° 5′ 0″ „ Sirius 23 36 0

Chronometer time corrected for mean of measurements.

Distances measured by sextant, which was corrected for Index Error.

Note on a Term in the Perturbations of the Moon, due to the Action of Mars. By E. Neison, Esq.

When at work in the beginning of 1877 on the theory of the perturbations of the Moon arising from the disturbing action of the planets, I was lead to approximately calculate the value of a number of terms of long period. One of these came out with a coefficient of several seconds of arc, it being the term with the argument

$$l - 24\,l'' + 20\,l''',$$

where l, l'', l''', denote the mean longitudes of the Moon, Earth and *Mars*. It so happened that this term closely represented in both amount and period the correction required to bring theory and observation into accord during the long period 1765–1851, as indicated by the residuals given by Sir George Airy in his reduction of the Greenwich Observations (see *M. N.* Nov. 1873). This led me to communicate this provisional result to the Society, with the caution that, from "the nature of the new term, it is obvious that the value which has been deduced for it in the present Paper is at best merely provisional. It will require most careful revision, and the higher powers of the disturbing forces must be taken into account. . . . . The existence of this term is so strongly supported by observation, from the manner in which it removes the discordance between theory and observation, that I have thought it better to publish it in its present form rather than defer this for the considerable period which may elapse before I am able to verify these results" (*M. N.* vol. xxxviii. p. 53).

At that time I had not discovered how much these outstanding residuals required correction for existing errors in the theory before they properly represented the difference between observation and theory, or I should not have attached such a great weight to this agreement as a confirmation of the accuracy of my rough calculation.

The value of the coefficient of this term entirely depends on the exact value of the very small difference of the sum of two long series of very large quantities of different signs, so that if each term of these series be not calculated with the greatest exactness, the difference between the sums of these two series may be entirely incorrect. In my calculations I had employed quantities extending to five places, which seemed amply sufficient; but in the course of the following year I found that this was not so, and that, in consequence, the difference between the sums of these two long series was far too great, so that the value found for the coefficient of this new term of long period was far too large. This fact I mentioned in my paper on "Hansen's Terms of Long Period" (*M. N.* March 1878, p. 269).

Since then I have more accurately computed the value of this part of this term, and find its true value to be only a small fraction of a second, instead of several seconds, and the calculation forms a portion of the second part of my still unpublished Memoir on the "Perturbations of the Moon due to the Action of the Planets."

Lately I have received from M. Constantin Gogau an elaborate investigation of this portion of the complete value of this term—that is, the portion arising from the direct action of *Mars* on the Moon as disturbed by the Sun. Adopting the method employed by Delaunay for determining the value of the similar inequalities computed by Hansen, M. Gogau has investigated with great care the exact analytical expression for the coefficient of this term of long period as far as the third power of the eccentricities and inclinations of the Earth and *Mars*, and the second power of the ratio of the mean motions of the Earth and Moon. Then, by reducing these analytical results to numbers, he arrives at the conclusion that the value of the coefficient of this term is so small a fraction of a second of arc that the term must be considered quite insensible.

M. Gogau seems to have thought that my provisional calculation was intended for a complete investigation, for he points out that I have neglected a number of small quantities which ought to be included in a complete determination of the value of this coefficient. This is, of course, obvious; but the omission was intentional, for, as I state in my Paper, I omitted these terms because they could not yield any sensible portion of the coefficient. M. Gogau also lays much stress on the fact that I have omitted to take into account certain terms which are independent of m, the ratio of the mean motions of the Earth and Moon; but these terms, though they do not implicitly involve m, are none the less dependent on the disturbing force of the Sun, and cannot therefore be properly included in any investigation in which this disturbing force is neglected, as I explicitly stated was the case in the present instance. As I have pointed out elsewhere (*M. N.* March 1878) these terms depending on the solar disturbing force cannot be of any material importance in these inequalities of long period, but can only form a very small fraction of the value which is independent of them. Their consideration gives rise to an enormous increase in the labour of the investigation, but, as M. Gogau's results clearly show, their omission would not affect the conclusions in any material degree.

In so far as they extend, M. Gogau's results appear accurate. But they do not form a satisfactory determination of even this part of the complete coefficient, for they are not sufficiently extended. The terms depending on the fifth and seventh powers and products of the eccentricities of *Mars* and the Earth are capable of yielding far larger quantities than found to result from the third powers, and until it be shown that the mutual destruction of terms is as complete amongst the higher powers

and products as it is amongst the lowest, the exact value of the coefficient cannot be held to have been satisfactorily determined. But M. Gogau has entirely neglected these terms, whereas in my investigation I retained them; hence his result is not sufficiently complete.

It is further to be noted that this elaborate investigation of M. Gogau, which reflects so much credit on its author, forms only the smaller portion of the complete work of determining the true value of this term of long period due to *Mars*, for, like Delaunay, he has entirely omitted to consider the difficult but most highly important effects arising from the direct action of the Sun on the perturbations in the motion of the Moon due to the direct action of *Mars*. But, as Hansen found, their indirect effect may be much more important than the direct effect of the planet. So until this additional portion of the complete value of the coefficient of this term has been computed, it cannot be said that the value of this term has been shown to be insensible, as M. Gogau believed he had done in his fine Memoir.

London:
1882, *February* 15.

On the Correction to the Horizontal Diameter of the Moon, from the Observations made between 1851 *and* 1858. By James Campbell, Esq., and E. Neison, Esq.

In his Paper in the *Monthly Notices* for December 1881, p. 64, Mr. Stone states that he deduces from the Greenwich Observations for the years 1851–58 a very different value for the correction to the tabular semi-diameter to that given by us in our Paper as the correction deduced by one of us (Neison). It is necessary for us, therefore, to publish the details of this investigation made by Mr. Neison some years ago.

The determination of the correction to the semi-diameter may be divided into two portions—one, 1851–55, when it is necessary to correct the value of the semi-diameter given in the *Nautical Almanac* for the errors in Burckhardt's tables, by applying to the parallax and semi-diameter the corrections deduced by Adams, and given in the *Nautical Almanac* for 1856; and the other for the years 1856–58, where no such correction is required, as Adams's corrected parallax and semi-diameter were used in the *Nautical Almanac*.

Let

S_a = Adams's original value of the mean semi-diameter of the Moon,

δS_a = Correction to this value given by the Greenwich Observations,

S'_h = Tabular horizontal semi-diameter of the Moon (apparent),

S'_v = Tabular vertical semi-diameter of the Moon (apparent);

and put

$\Delta S'_a$ = Adams's correction to Burckhardt's tabular parallax,

$\Delta P'_a$ = Adams's correction to Burckhardt's tabular semi-diameter,

C_b = Observed correction to Burckhardt's horizontal semi-diameter,

C_a = Observed correction to Adams's horizontal semi-diameter.

Then

$$C_a = C_b + \Delta S'_a \times \frac{S'_h}{S'_v},$$

and

$$\delta S_a = C_a \times \frac{S}{S'_h} = \left(C_b + \Delta S'_a \times \frac{S'_n}{S'_v}\right)\frac{S}{S'_h}$$

$$= C \times \frac{S}{S'_h} + 0{\cdot}2725\, \Delta P'_a \times \frac{S}{S'_v};$$

where

S = Mean tabular semi-diameter = $932''{\cdot}5$ approximately.

In both Burckhardt's tables and in Adams's original value, the semi-diameter is obtained by multiplying the parallax by the constant 0·2725. Burckhardt's value for the constant of parallax is $(57'\ 0''{\cdot}5)$, so that his value for the mean semi-diameter is

$$(57'\ 0''{\cdot}5\ ) \times 0{\cdot}2725 = 15'\ 32''{\cdot}09.$$

The constant of parallax adopted by Adams is different, however, and is explicitly stated by him in the introduction to his supplementary tables (*Naut. Alm.*, 1856) to be $(57'\ 2''{\cdot}325)$, hence the value of Adams's original mean semi-diameter is

$$(57'\ 2''{\cdot}325) \times 0{\cdot}2725 = 15'\ 32''{\cdot}57,$$

or greater than Burckhardt's by $0''{\cdot}48$.

From the different volumes of the Greenwich Observations and the corresponding volumes of the *Nautical Almanac* are derived the quantities:—

No.	Date.	Approximate Hor. Semi-d.	Approximate Vert. Semi-d.	Mean semi-dia. / Hor. semi-dia.	Mean semi-dia. / Vert. semi-dia.	$\Delta P'_a$	Corr. applied in *N.A.* to Burckhardt's Tab. Value.
		s	″			″	s
1	1851, Feb. 15	72·4	1·019	12 88	0·915	+0·8	+·00
2	May 14	68·1	·964	13·70	0·968	+0·7	+·00
3	June 13	68·5	·930	13·61	1·003	+3·0	+·00
4	July 12	67·4	·910	13·84	1·025	+4·1	+·00
5	Aug. 11	63·9	·893	14·58	1 044	+3·6	+·00
6	Sept. 9	62·1	·889	15·03	1·049	+1·8	+·00
7	1852, March 5	70·6	1·013	13·22	·921	+4·0	+·00

No.	Date.	Approximate Hor. Semi-d.	Approximate Vert. Semi-d.	Mean semi-dia. / Hor. semi-dia.	Mean semi-dia. / Vert. semi-dia.	$\Delta P'a$	Corr. applied in *N.A.* to Burchhardt's Tab. Value.
		s	"			"	s
8	1852, May 3	70·8	1·004	13·17	·929	+2·5	+·00
9	Nov. 26	65·2	·902	14·31	1·034	+1·5	+·00
10	1853, Mar. 24	68·3	·995	13·65	·950	+2·6	+·19
11	May 22	74·2	1·013	12·57	·921	−2·1	+·21
12	Sept. 16	65·1	·940	14·33	·993	+1·8	+·18
13	Oct. 16	62·6	·914	14·91	1·020	+2·4	+·17
14	1854, Feb. 12	66·2	·921	14·09	1·013	+0·4	+·18
15	June 10	75·6	1·006	12·34	·927	−1·6	+·22
16	Sept. 6	68·8	·996	13·56	·937	+2·8	+·19
17	1855, March 3	62·5	·905	14·93	1·030	−1·0	+·17
18	July 28	76·9	1·004	12·13	·929	+·8	+·22
19	Sept. 25	69·1	1·009	13·50	·924	+1·5	+·19

The observations made by computers or other less experienced observers are marked with an asterisk, and, as stated on p. 443 of our paper, are rejected as liable to unknown error.

No.	Obs. Corr. to *Naut. Alm.*	Cb	$Cb \times \frac{S}{S'h}$	$0'2725 \frac{\Delta P'a}{S'} \times \frac{S'}{S'v}$	δSa
	s	s	"	"	"
1	−·17	−·17	−2·20	+0·20	−2·00
2	−·18	−·18	−2·47	+0·19	−2·28
3	−·18	−·18	−2·45	+0·82	−1·63*
4	−·20	−·20	−2·77	+1·19	−1·58
5	−·17	−·17	−2·58	+1·03	−1·55
6	−·19	−·19	−2·86	+0·52	−2·34
7	−·23	−·23	−3·04	+1·00	−2·04
8	−·29	−·29	−3·82	+·63	−3·19
9	−·29	−·29	−4·15	+·43	−3·72
10	−·05	−·24	−3·27	+·67	−2·60
11	−·19	−·40	−5·03	−·52	−5·55
12	−·07	−·25	−3·58	+·48	−3·10
13	−·15	−·32	−4·77	+67	−4·10
14	+·01	−·17	−2·39	+·11	−2·28
15	+·16	−·06	−·74	−·41	−1·15*
16	+·01	−·18	−2·44	+·71	−1·73
17	+·09	−·08	−1·19	−·28	−1·47*
18	+·10	−·12	−1·45	+·20	−1·25
19	−·05	−·24	−3·24	+·38	−2·86

Hence we have

1851	6 obs. =	−1″·90.	Excluding computers, 5 obs. =	−1″·95
1852	3	−2·97.	3	−2·97
1853	4	−3·84.	4	−3·84
1854	3	−1·72.	2	−2·01
1855	3	−1·86.	2	−2·06

For the year 1856 the value employed in the *Nautical Almanac* was derived from Adams's parallax multiplied by the constant 0·2725. The tables require no correction, and the corrections to the *Nautical Almanac* given by the Greenwich Observations yield directly the correction of the semi-diameter.

For this year, then, we have

Date.	S′h	$\frac{S}{S'h}$	Cα	$C\alpha \times \frac{S}{S'h}$
	s			″
1856, May 19	68·4	13·63	−·07	−·95
Aug. 15	72·2	12·93	−·01	−·13*
Oct. 13	70·5	13·24	−·00	−·00

Hence

1856	3 obs. =	−0″·36.	Excluding computers, 2 obs. =	−″·48.

For the two years 1857–58 the value employed in the *Nautical Almanac* was derived from Adams's parallax multiplied by the constant 0·273114. Hence the mean diameter, instead of being 15′ 32″·57, was

$$(57' 2''\cdot325) \times 0\cdot273114 = 15' 34'\cdot68,$$

or 2″·11 larger. For these years we have

Date.	S′h	$\frac{S}{S'h}$	Cα	$C\alpha \times \frac{S}{S'h}$
	s			″
1857, May 8	65·0	14·36	−·11	−1·58
Nov. 1	73·3	12·73	+·20	+2·55*
Dec. 30	78·7	11·84	+·11	+1·30
1858, Feb. 27	66·0	14·13	−·02	−0·28
July 25	66·9	13·95	+·05	+0·69
Sept. 22	64·6	14·45	+·10	+1·45
Oct. 22	70·2	13·30	+·15	+2·00
Nov. 20	75·6	12·34	+·10	+1·23

Hence

1857	3 obs. =	+0′·76.	Excluding computers, 2 obs. =	−0·14
1858	5	+1·02.	5	+1·02

To reduce all the results to the same value of the semi-diameter—namely, that commonly called Adams's value, and used in the *Nautical Almanac* for 1857–61—those for the years 1851–56 must be increased by $+2''\cdot11$. Hence the entire series become

1851	6 obs.	$+0''\cdot21$.	Excluding computers	5 obs.	$+0''\cdot16$
1852	3	$-0\cdot86$.		3	$-0\cdot86$
1853	4	$-1\cdot73$.		4	$-1\cdot73$
1854	3	$+0\cdot39$.		2	$+0\cdot10$
1855	3	$+0\cdot25$.		2	$+0\cdot05$
1856	3	$+1\cdot75$.		2	$+1\cdot63$
1857	3	$+0\cdot76$.		2	$-0\cdot14$
1858	5	$+1\cdot02$.		5	$+1\cdot02$

Multiplying each of these by the number of observations and taking the means, we have

30 obs. $= +0''\cdot21$. 24 obs. $= -0''\cdot01$

As explicitly stated by us, the observations of the computers were excluded; hence we have for the correction to the tabular semi-diameter $= -0''\cdot01$, or for the observed semi-diameter

$$(15'\ 34''\cdot68)-(-\cdot01) = 15'\ 34''\cdot69.$$

This result is exactly the same as that obtained by a second computation made by using the corrections to the actual diameter, instead of the semi-diameter, by which the necessity of dividing the corections by two was avoided.

The only other point raised by Mr. Stone which need be considered is, how far we are right in believing the large apparent value of the parallactic inequality obtained from the observations of the years 1846–50 to be probably due to the repeated changes in the observers during those years. Previous to 1846 Mr. Ellis seems to have made the greater number of observations, whilst subsequent to that year he made very few; and we point out that as Mr. Ellis seems to have made the correction to the diameter of the Moon nearly $3''$ greater than the other observers, the cessation of his observations must have tended to have raised the apparent value of the parallactic inequality.

This is questioned by Mr. Stone, who from *four* observations of the horizontal diameter of the Moon made by Mr. Ellis, as compared with twenty-three by other observers, shows that Mr. Ellis's value only exceeds those of the other observers by $1''\cdot94$.* But during the period covered by the observations quoted by Mr. Stone the instrument with which they were made was changed, and to obtain comparable results it is necessary to ex-

* These are taken direct from Mr. Stone's figures. There are two or three small errors in this portion of his paper.

clude the year 1851 and restrict ourselves to the consideration of the years prior to 1851, when the observations were throughout made with the old Transit Instrument. Employing, then, the twenty observations made between 1843 and 1850, we find from *three* observations of Mr. Ellis, as compared with seventeen by other observers, that the mean of the former exceeds the mean of the latter by $2''{\cdot}62$. This result practically accords with those obtained by us; but we demur to the idea that any trustworthy results can be obtained from the comparison of only three or four observations of Mr. Ellis with other data. Our own statement that the correction to the lunar diameter according to Mr. Ellis exceeded that according to the three other observers, Messrs. Henry, Rogerson, and Dunkin, by nearly $3''$, was founded on the direct comparison of all their observations, made during the years 1843–50, taking Mr. Henry, who regularly observed throughout the entire period, as the standard observer. This comparison yielded the following results:—

Correction to diameter.

Henry – Rogerson	$= +0''{\cdot}1$.	From 174 obs. of the limb, and 8 obs. of diameter.
Henry – Dunkin	$+0''{\cdot}2$.	From 147 obs. of the limb.
Henry – Ellis	$+2''{\cdot}9$.	From 325 obs. of the limb, and 8 obs. of diameters.

As in the determination of the parallactic inequality, the correction to the assumed diameter enters multiplied by a factor whose mean value may be taken as $0{\cdot}75$, it follows that the value found from Mr. Ellis's observations requires the correction $2''{\cdot}9 \times 0{\cdot}75 = 2''{\cdot}17$ to bring it into accord with the value according to Mr. Henry's observations. Hence, owing to the cessation of Mr. Ellis's observation in 1846, it follows that the value of the parallactic inequality found for that year requires a correction of over $1''$ to bring it into harmony with the values found for previous years. Similar corrections must also be applied to the results for the other subsequent years.

This correction does not completely remove the discordance between the results obtained from the observations made during the short period 1846–50, and the long series prior to 1846. But it weakens its weight enormously. Further examination would probably reveal other causes; but the existence of this discordance is not of sufficient importance to render its removal worthy of the labour involved. To us it seems that this admitted discordance of four or five years in a period of one hundred and twenty cannot be held to be serious, when it is known to be coincident in period with the introduction of more inexperienced observers, and vanishes as soon as these observers become more experienced, as in the period 1851–58.